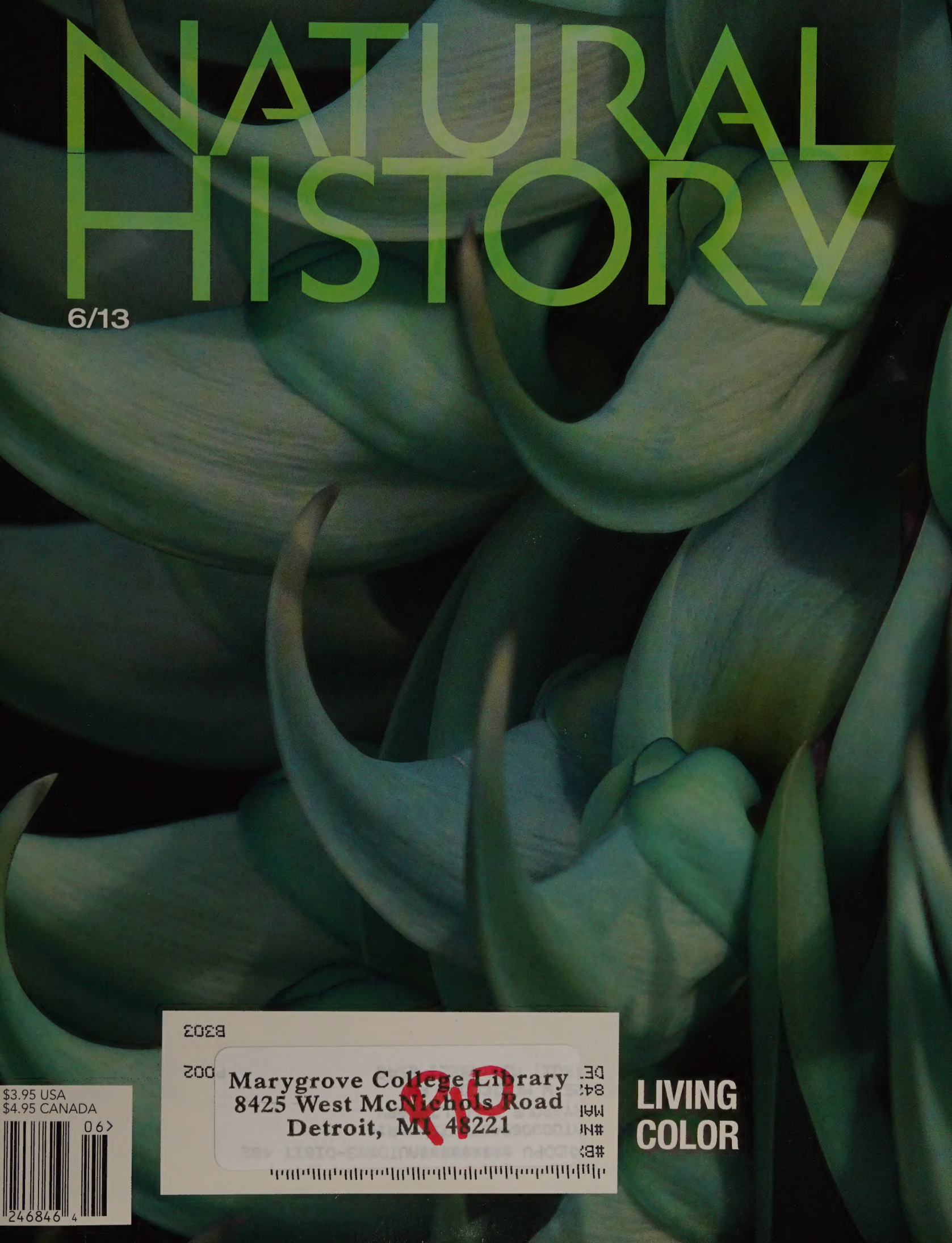

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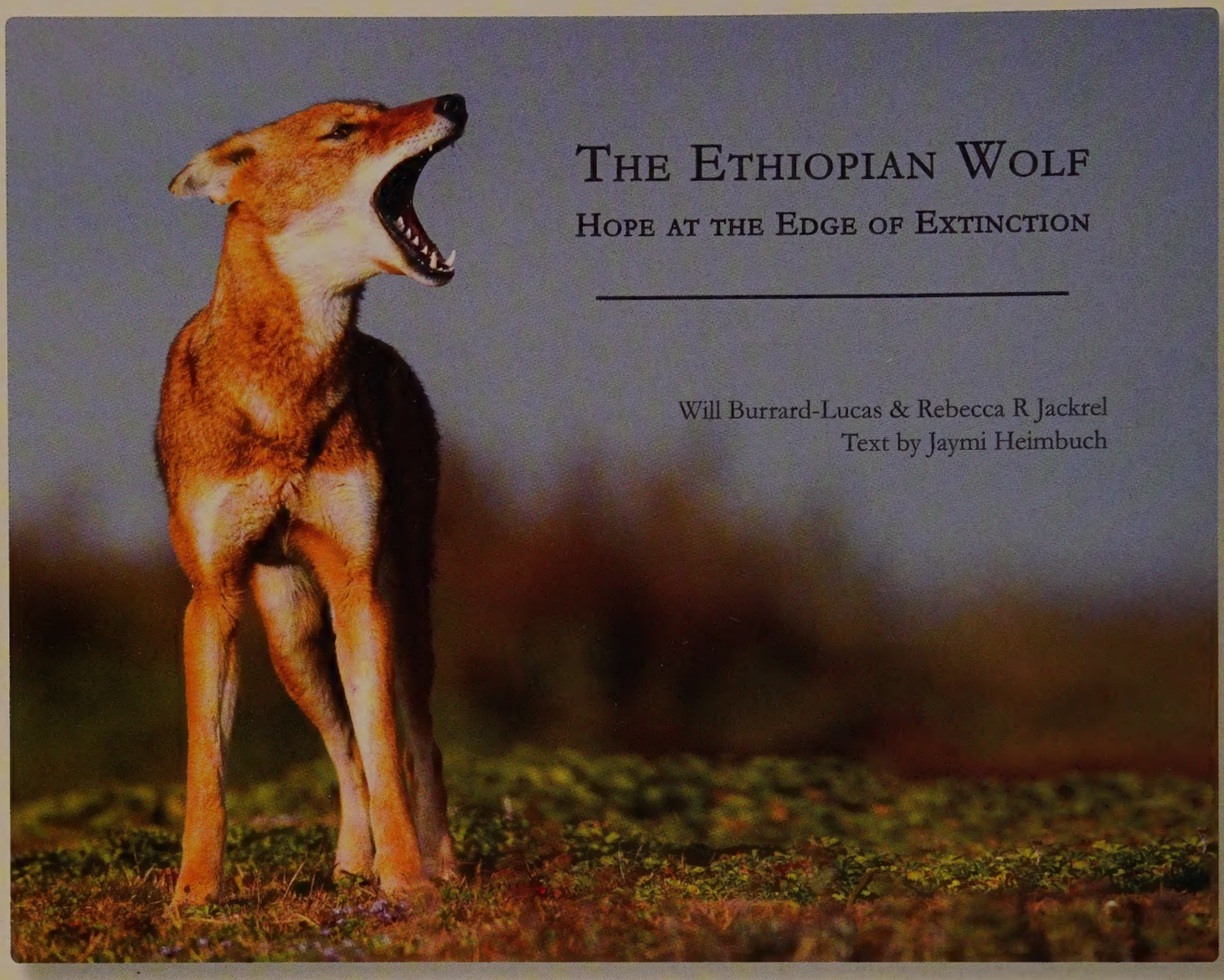

The Ethiopian Wolf: Hope at the Edge of Extinction

Will Burrard-Lucas and Rebecca R Jackrel
Text by Jaymi Heimbuch

The Ethiopian wolf hangs precariously close to extinction with fewer than 450 individuals left on the planet. But this little-known species also offers us one of the greatest stories of hope for successful conservation today. Witness the intimate pack lives of the wolves. Enjoy the landscapes they call home—beautifully captured by wildlife photographers Will Burrard-Lucas and Rebecca R Jackrel. Learn how these wolves are becoming a symbol for what can be accomplished by dedicated individuals set on saving a species from extinction.

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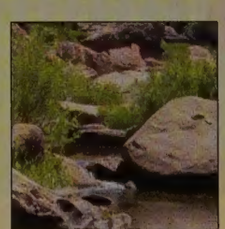
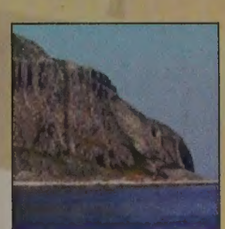
JUNE 2013 VOLUME 121 NUMBER 5

FEATURES

COVER STORY

DEPARTMENTS





ON THE COVER: *Jade vine (*Strongylodon macrobotrys*) blooms in the Chicago Botanic Garden.*
Photograph © Don Burkett

BACKGROUND, MICHAEL HORVATH

THE NATURAL MOMENT

BARK TENDERS

Photograph by Alex Wild

◄ *See preceding two pages*

THE NATURAL EXPLANATION

BY ERIN ESPELIE

Trophy hunting for Alex Wild, who goes on frequent expeditions around the world, means taking home prize portraits of ants that you would want to hang on a wall: ants on a slave raid; ants weaving leaf cabanas; ants mining charcoal or milling seeds with their mandibles. Yet along the trail other game invariably catches his entomological eye, as happened last year in central Colombia, where Wild was drawn to two species of barklice [*one pictured above and another on the preceding pages*]. "It's as if I'm on a safari looking for lions, but can't ignore these herds of wildebeests."

Barklice, Wild points out, can be spotted nearly everywhere you find trees—just look closely at any patch of darker bark on the trunk. The wildebeest analogy fits barklice well: they travel in herds and forage upon vegetarian fare, such as lichen, fungi, and algae. Such grazing doesn't damage any of a tree's living tissue, and may even offer benefits by swabbing off bark detritus.

Barklice are near kin to booklice, which feed on the mold and paste in old books and under wallpaper. Both creatures are often classified in the order Psocoptera. Psocopterids, of which there are some 3,200 species worldwide, also include parasitic "chewing" lice and are known, from both morphology and genetics, to be close relatives of the parasitic "true" (sucking) lice. All these insects are now classified in the superorder Psocodea.

A study published this spring in *PLoS ONE* goes further, to link barklice, booklice, and parasitic lice by analyzing their mitochondrial DNA (mtDNA). Results show that the mtDNA of lice rearranges to a degree highly unusual among insects. It does so particularly rapidly in booklice and parasitic lice, a trait the scientists attribute to "lifestyle change." Barklice mtDNA is more laid back. Trees, it seems, have been a more stable food source than people and our printed matter.

Equipped with a PhD in entomology from the University of California, Davis, **Alex Wild** devotes his time to photographing insects, writing about the field in his blog for *Scientific American* (aptly titled "Compound Eye"), and teaching occasionally at the University of Illinois at Urbana-Champaign. He also leads photography workshops through BugShot. His images of ants and other insects can be viewed at www.alexanderwild.com.

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Natural History (ISSN 0028-0712) is published monthly, except for combined issues in July/August and December/January, by Natural History Magazine, Inc., P.O. Box 110623, Research Triangle Park, NC 27709-5623, in affiliation with the American Museum of Natural History. Natural History Magazine, Inc. is solely responsible for editorial content and publishing practices.

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Fire Fight

As we go to press the tragic news from Arizona is that an out-of-control forest fire trapped and killed nineteen firefighters. Wildfires have been devastating parts of the United States in recent months, but such a loss of life is sobering.

In Colorado firefighters recently found themselves battling the Black Forest Fire, the wildfire most destructive of human habitation in Colorado history, even as scientists from the Warner College of Natural Resources at Colorado State University, in Fort Collins, had begun a large-scale impact study of last year's High Park Fire, one of the state's largest in terms of acreage. In partnership with Colorado's newest research facility, the National Ecological Observatory Network (NEON), headquartered in Boulder, the study is "providing critical data to communities still working to repair and restore major water quality, erosion and ecosystem restoration issues in an area spanning more than 136 square miles." The National Science Foundation supports the study and NEON, and NSF's website includes a video about the rapid-response team that began the research soon after last year's fire was under control, and the techniques they used to collect data (www.nsf.gov/news/special_reports/science_nation/neon.jsp?WT.mc_id=USNSF_51).

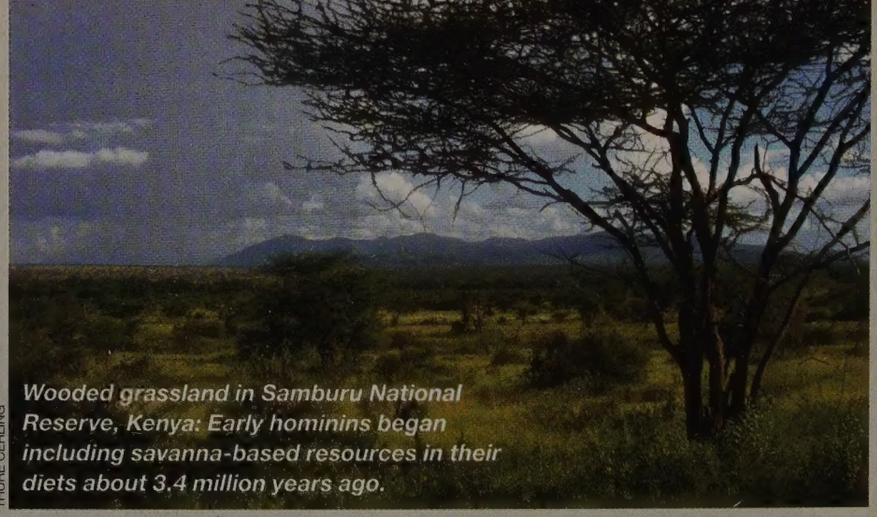
U.S. FISH AND WILDLIFE SERVICE

Before the 2012 drought that created the conditions for Colorado's historic blazes, the state's climatologist, Nolan Doesken, "rarely included many of his thoughts on human-caused climate change in his drought and water reports to Colorado's agriculture and water communities." Now he doesn't hesitate to share his views with some of the state's biggest climate-change skeptics (www.coloradoan.com/article/20130523/NEWS01/305230049/Colorado-s-state-climatologist-says-High-Park-Fire-granted-him-permission-courage-talk-about-climate-change).

How best to fight wildfire—when what's bad for human life and real estate may be an essential component of natural cycles—is a complex question, only made more confounding when human impact makes wildfires far more intense and prescribed burns harder to control. In a recent study reported in the May issue of *Natural History* and on our website, a team of Dutch and Portuguese scientists found a surprising relationship between aboveground fire intensity and soil temperatures—and consequently, soil damage (www.nhmag.com/samplings/182514/scorched-earth-policy). Similarly, after the large Cedar Fire in October 2003 in San Diego County, California, a group of scientists, including two from the San Diego Natural History Museum, studied the effect of fire severity on small mammals. Results of the study were published online in February 2012 in the *International Journal of Wildland Fire* (the scholarly paper may be downloaded at sdnhm.org/science/birds-and-mammals/projects/post-fire-studies-mammals/concl). The abstract, introduction, and conclusion are probably enough for most to understand there is a need for novel fire management strategies.

For our small-mammal ancestors who survived the giant meteorite impact on Earth 66 million years ago, however, today's fires would seem mild—see www.nhmag.com/samplings/172515/heated-debate.

Evolving Tastes



THURE CERLING

Wooded grassland in Samburu National Reserve, Kenya: Early hominins began including savanna-based resources in their diets about 3.4 million years ago.

Four new studies have revealed a fundamental change that occurred in the diets of our primate ancestors. Until about 4 million years ago, hominins—the line of primates that includes early humans and their extinct ancestors—mostly ate leaves and fruit available in forested habitats, as did the modern apes' ancestors from which they had begun to diverge. Then, some hominins started to expand their menu and dining locales.

The research, spearheaded by Thure E. Cerling, a geochemist at the University of Utah, involved more than twenty scientists who studied enamel samples from 173 teeth belonging to eleven hominin species. Enamel incorporates traces of the element carbon from consumed food. Some plants obtain their energy via a particular chemical pathway known as C3 photosynthesis; others—typically tropical grasses and sedges—use a different pathway, dubbed C4 photosynthesis. The two pathways preferentially store different isotopes, or variants, of carbon, so measuring those isotopes in small amounts of enamel drilled from fossil teeth can inform us about ancient species' diets.

C4 plants appeared on East African savannahs 6 million or 7 million years ago, but analysis of carbon isotopes in the teeth showed that the older hominin diet had relied on C3 plants, pointing to a diet of fruits and leaves. This had previously been known for *Ardipithecus ramidus* (which lived 4.4 million years ago) and now has also been shown for *Australopithecus anamensis*, whose fossils date from about 4.2 million to 4 million years ago. Then, about 3.4 million years ago, certain hominins, such as *Australopithecus afarensis* and *Kenyanthropus platyops*, began using savanna resources either by munching on tropical grasses and sedges or eating the animals that partook of C4 plants. Less than a million years later, other species such as *Australopithecus africanus* and *Paranthropus robustus* had switched diets to a mix of C3 and C4 plants.

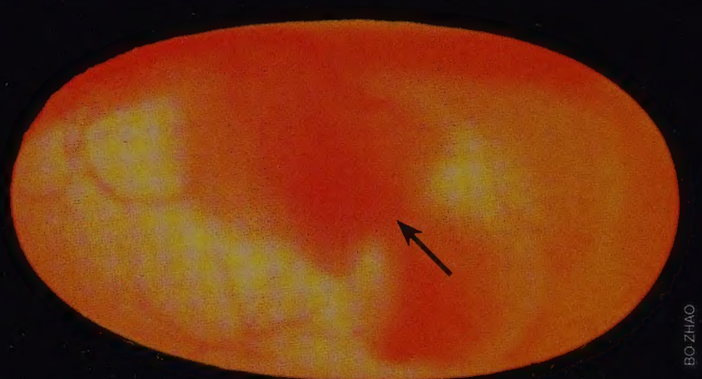
We modern hominins still eat a mix of C3 and C4 foods. On the other hand, chimpanzees and gorillas, our closest living relatives, are C3-centric. The inclusion of C4 food was a game changer from a behavioral standpoint: our relatives had to leave the forests to access those dietary resources and adapt to an open grassland environment. Thus, diet is considered a powerful driver of human evolution, possibly contributing to the rise of upright walking and larger brains.

"With these studies, instead of seeing the picture piecemeal, we're able to see the whole picture over three or four million years all at once," said Cerling, and added: "Now it's time to go for some of the wild and not-so-wild speculation" on the evolutionary ramifications of our ancestors' broadened menu. (*PNAS*)

—Adam Hadhazy

The Inside Story

When lined up on a log or crowded onto a rock on a sunny morning, aquatic turtles get their "cold blood" flowing by basking. If it gets too warm, they just slip into the shade or dive into the cool depths of a pond. With this behavior, such ectotherms can control their internal temperature with some precision, but when exactly do they acquire that essential ability?



BO ZHAO

The position of a Chinese three-keeled pond turtle embryo inside the egg is shown by candling. The head is at lower right; the arrow indicates where the neck joins the carapace.

In 2011, Wei-Guo Du of the Chinese Academy of Sciences in Beijing and colleagues first revealed that embryos of the Chinese soft-shelled turtle, *Pelodiscus sinensis*, gravitate toward warmth even before hatching. More recently, Du and three colleagues delved further into the remarkable phenomenon with eggs of the Chinese three-keeled pond turtle, *Chinemys reevesii*. In the lab, by candling—holding the eggs up to light—the scientists noted the position of embryos ten days into the approximately sixty-day incubation process. They then used heat pads to warm portions of the surface of each egg to different temperatures, ranging from 82 to 91 degrees Fahrenheit.

Seven days later, they rechecked the position of the embryos. If the temperature was mild and constant, the tiny inhabitants stayed put in mid-egg. A warm spot up to 86 degrees at one end of the egg attracted the embryos, while hot spots of more than 91 degrees repelled them. The researchers found that the behavior is active, and analogous to thermoregulation in hatchlings and adults.

In the wild, females of this species lay a clutch of about six eggs in a hole on the banks of a pond and cover it with vegetation. As in some other reptiles, the temperature of the eggs determines the sex of the hatchlings. In this case, mixed-sex clutches are produced when the temperatures are around 84 degrees, while mostly males emerge with cooler, and females with warmer, conditions. Some scientists have raised concerns that climate change may affect nest temperatures and thus skew sex ratios in turtle species. These researchers note that, beyond placement of nests by mothers, embryonic adjustments may help offset uneven sex ratios. (*Biology Letters*)

—Judy Rice

C-A-S-H Machine

Rome wasn't built in a day, but it was built to last. In particular, Roman harbors, integral to the empire's maritime economy, were cast in a unique concrete so durable that 2,000 years of immersion in the Mediterranean Sea have done little to degrade their impressive piers and breakwaters. Yet the precise mineralogical makeup of Roman seawater concrete—and the secret to its success—had remained a maritime mystery until now, when an international research team of engineers and geologists put this material under the microscope.

Concrete block at Caesarea harbor, constructed on the coast of Israel in the late first century BC

M.D. JACKSON ET AL., *AMERICAN MINERALOGIST*, IN PRESS

Sample of concrete with mortar made from hydrated lime and volcanic ash (inclusions: white = relict lime clasts; dark gray = lava lithic fragments; brown = pumice clasts)

Led by Paulo J. M. Monteiro and Marie Jackson at the University of California, Berkeley, the team subjected a chunk of concrete drilled from a first-century BC Roman breakwater near Naples, Italy, to a suite of fine-scale physical and chemical studies. Today's concrete is held together by a binding agent called "Portland cement," which is created in the highly carbon-intensive process of heating a clay-limestone blend to 2,642 degrees Fahrenheit. The analysis shows that Romans, on the other hand, derived lime for their concrete by baking limestone at temperatures 1,000 degrees lower. Then, they combined the lime with volcanic ash to make mortar and poured it, together with volcanic rocks, into wooden molds under seawater. The lime reacted with water and the ash in a chemical reaction that heated the mix to about 185 degrees and bound it with an incredible strength that may have continued to increase for many years. The concrete remained warmer than the surrounding seawater for as long as two years.

It is during this reaction, the researchers confirmed, that the resulting cementing compound, known as calcium-aluminum-silicate-hydrate (C-A-S-H), rearranges its crystal structure, replacing some silicon ions with aluminum ions. They also discovered large, stable crystals of the rare mineral known as aluminum tobermorite. The group determined that it is the presence of both these compounds that holds the key to the concrete's durability. Although the Roman recipe hardens too slowly for today's fast-paced construction, this study paves the way for improving modern concrete's strength and reducing its carbon emissions by replacing some Portland cement with plentiful volcanic ash. (*Journal of the American Ceramic Society*) —*Ashley Braun*

Camponotus schmitzi *workers retrieve a drowned cockroach from the fluid inside a pitcher.*

MATHIAS SCHARMANN

Ants in Their Plants

The carnivorous pitcher plant *Nepenthes bicalcarata* grows in peat swamps low on nutrients. To satisfy its needs, the plant attracts and consumes insects, especially ants, which slip into and drown in its pitchers—jug-shaped leaves partially filled with acidic digestive fluids. Yet this ant-hungry pitcher plant has an unusual inhabitant and partner: the ant *Camponotus schmitzi.* This ant lives exclusively on Bornean *N. bicalcarata,* licking nectar while balancing on pitchers' slick rims and even diving into their fluids to fish out and eat entrapped prey. Researchers have discovered a paradox: the seeming thieves in fact bestow an extensive nutritional benefit—plants with *C. schmitzi* ants "out-flourish" those without. But how do nutrients travel from ant to plant?

Mathias Scharmann and a team of fellow insect biologists at the University of Cambridge, United Kingdom, and the University Brunei Darussalam, Brunei, ventured into Borneo's northern forests. First, they sampled background levels of the rarer of the two stable nitrogen isotopes, ^{15}N, in leaves of *N. bicalcarata* plants, both colonized and uncolonized by *C. schmitzi* ants, as well as in the leaves of non-carnivorous reference plants, potential prey insects, larvae that hatch in the pitchers, pitcher plant detritus, and *C. schmitzi* ants. This allowed the researchers to calculate and compare the pitcher plants' ratio of soil nitrogen to insect-prey nitrogen, which is comparatively enriched in ^{15}N. Next, they fed even higher concentrations of ^{15}N to *C. schmitzi* colonies, using it as a tracer to follow whether and how nitrogen transferred to the pitcher plants. Finally, they recorded the ants' behavior toward and impact on the prolific population of mosquito and midge pupae and larvae living in the pitcher fluid. As these aquatic young insects develop, they devour *N. bicalcarata's* hard-won prey. When they leave as adults, those nutrients fly off too.

Scharmann and colleagues found that *C. schmitzi* colonies aggressively hunt these pupae and larvae in the pitcher plants' fluid—and excrete back into the fluid valuable nitrogen that would otherwise be lost as adult mosquitoes and midges emerge. As a result of this relationship, unique among carnivorous plants, *N. bicalcarata* plants colonized by ants retain more nutrients, grow faster, and derive essentially all their nitrogen from prey insects, not soil. (*PLOS ONE*) —*A. B.*

Bat Tweets

Humans can recognize familiar voices and discriminate even between unfamiliar ones. That ability depends on the processing of signature sounds in specific regions of the brain. Bats are highly social mammals that use vocalizations to communicate with each other. Can they discriminate between different bat voices?

HANNA B. KASTEIN

Indian false vampire bats hang out in their flight room.

Hanna B. Kastein and collaborators at the University of Veterinary Medicine in Hanover, Germany, studied Indian false vampire bats, *Megaderma lyra,* which have a complex social structure and individualized relationships. At night, between foraging bouts, bats cluster at roosts in small groups of three to six individuals, often in trees. As social partners, bat buddies are in close contact, sometimes hanging belly-to-belly.

The researchers trapped bats from two populations in South India, labeled them, and kept the members of the two populations in two separate "flight rooms." They observed which bats had frequent body contact, isolated them, and recorded the sounds they emitted, presuming the lonely bats would be calling for their buddies. Then, the team took separated bats into playback experiments where a bat hung at a perch and listened to different types of recorded contact calls: from bat "buddies," with which the isolated bat either had or did not have body contact, and from "strangers," bats belonging to the other group.

The researchers expected a stronger reaction to calls from body-contact buddies but, surprisingly, the listening bats were equally interested in any bat call. So, using a similar setup, the researchers played calls from a bat buddy until the listening bat stopped responding, having become habituated to that call. Only then they played either a call from the same buddy, other buddies, or a stranger. This time, the listening bats' response was significantly stronger to the call from a second bat than to a novel call from the first bat. This suggests that bats were able to discriminate between individuals. For the recognition of buddies by bats, the study found only an indication, however no evidence.

The bats could discriminate between different individuals on the basis of their voices, which have differences such as syllable duration, frequency, and inter-call interval, regardless of whether or not they knew the callers. The close relationship between call structure and bat response "has not been shown for another mammal before," says Kastein, and suggests that our human ability for voice recognition may have origins deep in our evolutionary past. (*Animal Cognition*)

—Lesley Evans Ogden

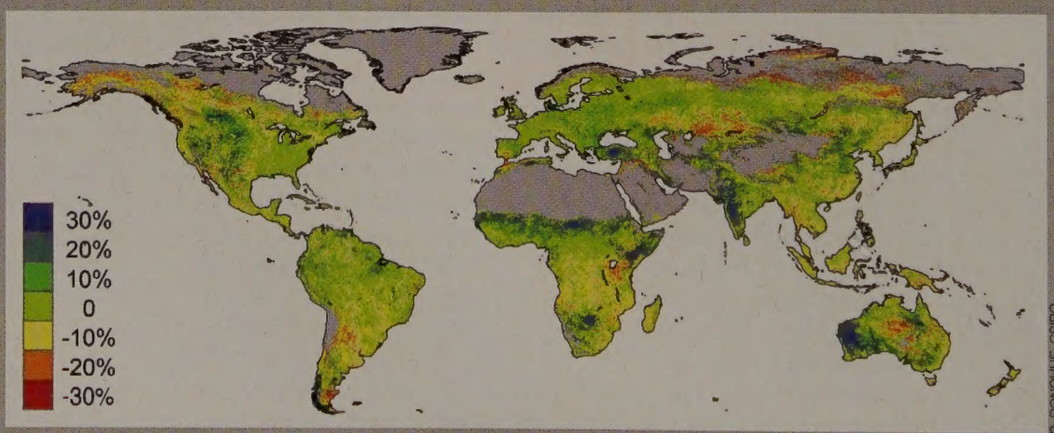
THE WARMING EARTH

Cover Story

The world's deserts and savannas for hunting and grazing have been greening over recent decades, increasing their foliage cover, and possibly even becoming woodier. Although changing rainfall patterns and rising temperatures—driven in part by increased atmospheric carbon dioxide (CO_2) concentrations—can play an important role in that process, scientists have long suspected that the greenhouse gas itself has a direct effect, because when more CO_2 is available, plants increase their rates of photosynthesis, and their growth is enhanced. The hypothesis has been difficult to prove, but now scientists have used satellite imagery and complex mathematical formulas to isolate the effect of "CO_2 fertilization."

Randall J. Donohue of the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in Canberra, Australia, and colleagues analyzed satellite observations gathered between 1982 and 2010. They concentrated on warm, arid environments—mainly in the Australian outback, the southwestern United States, the Middle East, and Southern Africa—where variation in the water supply plays a dominant role in regulating plant production, and chose locations where changes in the amount of light, nutrients, and land use are known to be minimal. This allowed a sharper focus on the effects of CO_2.

The researchers established a value for the maximum foliage cover than can be attained for a given annual rainfall when all other growing conditions are optimum, that is, everything else plants need is in abundance. The key to this maximum value is that there are very few processes that can increase it—the effects of variation in rainfall on foliage cover are already accounted for. Thus, any observed increases in those maximum values can be attributed, with reasonable confidence, to increased levels of CO_2.



R. DONOHUE, CSIRO

Percent change in leaf cover as detected from satellite between 1982 and 2010

The scientists' mathematical analyses predicted that in the arid areas studied, CO_2 fertilization would cause a 5 to 10 percent increase in maximum foliage coverage. They found that, indeed, controlling for other factors such as rainfall, the maximum foliage cover increased by 11 percent. (*Geophysical Research Letters*)

—Harvey Leifert

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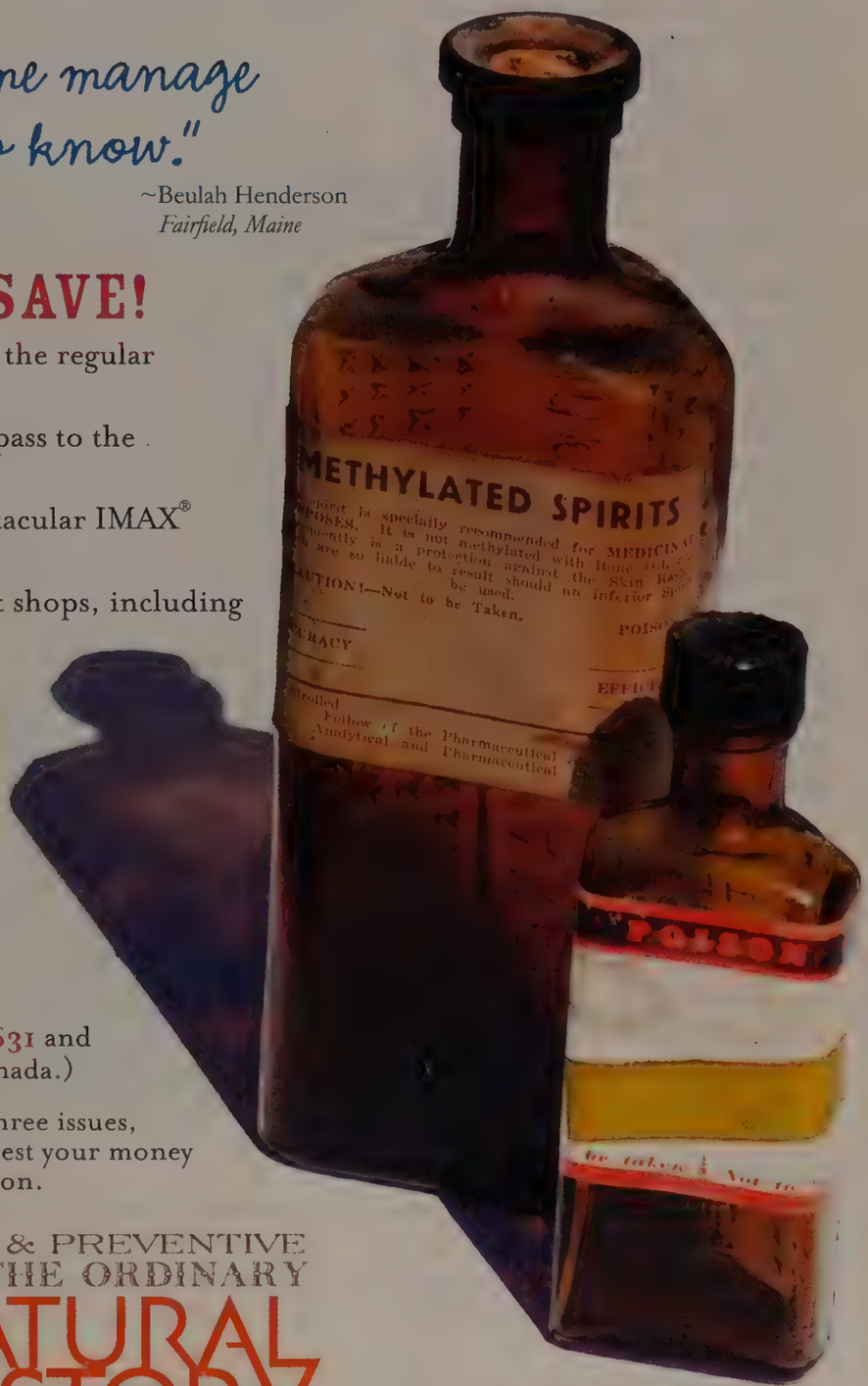

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Civil War surgeon's bloodletting lancets

BY DRUIN BURCH

Taken in Vein

The joy of bloodletting

There was once a barber surgeon named Theodoric of York. He was wrong about many things, but what he believed, he believed absolutely. Chiefly his faith was in the efficacy—for any condition, at any time, in any circumstances—of one particular medical intervention. This was all a long time ago, back in the early days of *Saturday Night Live,* and Theodoric was played by Steve Martin.

"Hello, Theodoric of York," says a character played by Dan Akroyd. "Well, it's springtime and I've come for my haircut and bloodletting." William survives his treatment, but things don't always work out so well at the barber's, and the problem isn't with the haircuts. Theodoric bleeds people, and they die. One recently deceased patient's mother complains, and complains bitterly. "Now, Mrs. Miller," says Theodoric, soothingly, "you're distraught, tired . . . you may be suffering from nervous exhaustion. I think you'd feel better if I let some of your blood."

THE BRITISH LIBRARY

An illumination of a medieval manuscript features bloodletting.

And so it goes, and so, in truth, it really went. Bloodletting was not practiced enthusiastically by the Sumerians and ancient Egyptians, but by the time of Classical Greece and Rome it was everything. The doctrine of the four humors held that health was determined by their balance. Perhaps because it wasn't so easy to open a patient's flesh and bring forth black bile, yellow bile, or phlegm, doctors took blood. It was quick and dramatic and everyone knew it helped.

Medical knowledge was solidified—clotted and congealed, it might be better to say—by Galen in the second century AD and passed on with more faith than testing until the Renaissance. Even then, the experimental method that was deployed to understand the natural world did not filter through to examining clinical choices. William Harvey revolutionized the way the body was perceived by discovering the circulation of the blood. His breakthrough prompted no changes whatsoever in therapies. Despite his highlighting the limited circulating volume that supports life, doctors never paused to reconsider their favorite remedy. The popularity of bleeding continued.

What's hard to keep in mind is that the people who believed in it, Theodoric aside, weren't comic fools. They included the most educated, observant, resourceful, compassionate, and rational. Based on theory, they had no doubt that bleeding helped. They could even see that a patient flushed with fever became pale and calm afterward. To us that might seem a joke. But if these people argued

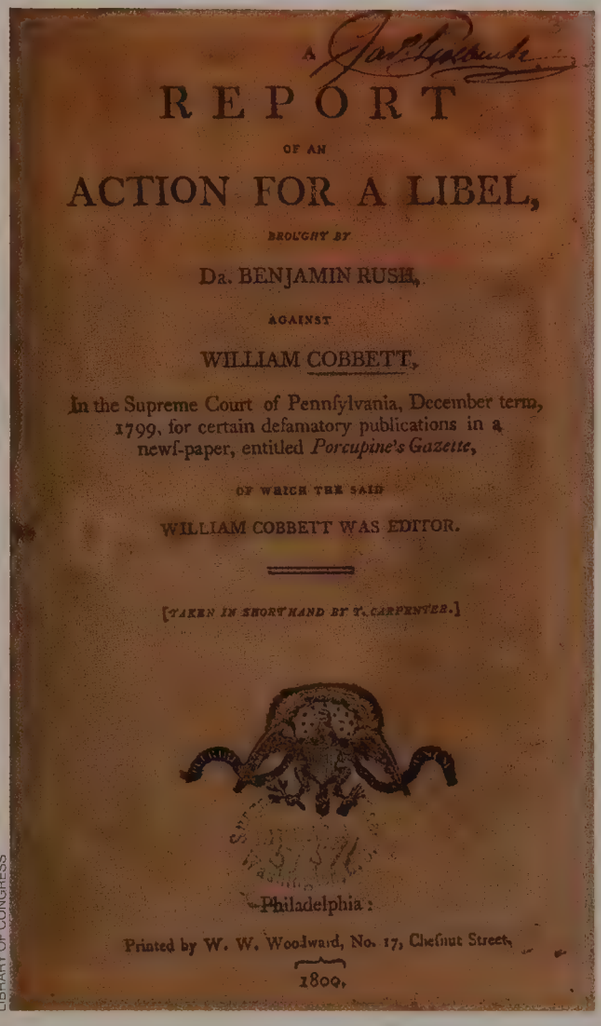
KANSAS MUSEUM OF HISTORY

about bleeding, it was about when to bleed and how much to bleed, not about bleeding's effectiveness.

The seventeenth-century Flemish chemist and physician John Baptista Van Helmont thought some physicians bled patients too much, and failed thereby to concentrate on what really worked. In his view, that was evacuation, meaning the use of drugs to get ill people to vomit and defecate themselves back into health. It was accepted that evacuation and bleeding were both good for you, but Van Helmont thought his contemporaries got the balance wrong. If you needed to pick just one of these two key therapeutic strategies, he felt he knew which it should be. But we could do better, he suggested, than rely on observation, intuition, and deduction. We could test our ideas; we could do trials. Van Helmont's bold, scientific proposal was set forward in a collection of his writings published by his son in 1648, four years after his death. "If ye speak truth," Van Helmont had argued,

> that ye can cure any kind of Fevers without evacuation . . . Let us take out of the Hospitals, out of the Camps, or from elsewhere, 200, or 500 poor People, that have Fevers, Pleurisies, etc. Let us divide them in halfes, let us cast lots, that one half of them may fall to my share, and the other to yours; I will cure them without bloodl-etting . . . we shall see how many Funerals both of us shall have.

With Theodoric of York, there was comedy in the inevitability. You knew his pride and pomp and confidence would prove less than totally congruous with reality. There's the same sense of inevitable failure in Van Helmont—somehow you don't need me to tell you that in the mid-1600s, having brilliantly explained how to properly investigate whether bleeding harmed or helped, neither he nor anyone else did anything of the sort. His experiment remained a mental one. Supporters and opponents alike conducted it in their own minds, and found—inevitably—that it confirmed their preexisting beliefs every time.


A REPORT OF AN ACTION FOR A LIBEL, BROUGHT BY Dr. BENJAMIN RUSH, AGAINST WILLIAM COBBETT, In the Supreme Court of Pennsylvania, December term, 1799, for certain defamatory publications in a newspaper, entitled *Porcupine's Gazette*, OF WHICH THE SAID WILLIAM COBBETT WAS EDITOR. [TAKEN IN SHORT HAND BY T. CARPENTER.] Philadelphia: Printed by W. W. Woodward, No. 17, Chesnut Street, 1800.

LIBRARY OF CONGRESS

In his Porcupine's Gazette, *William Cobbett attacked physician Benjamin Rush for the promotion of bloodletting, provoking a lawsuit for libel.*

It's an oddly unrecognized fact that the development of modern medicine owes more to method than to laboratory breakthroughs. It's not properly recognized precisely because we find it so easy to dismiss as silliness the errors of our bloodletting ancestors. When we think of what changed for the better, we most easily think of new technology, such as antibiotics; but what was more important was the introduction of experiments designed so they could distinguish help from harm. Sulfonamides and penicillin seemed like miracle cures, and in a few settings they really were. In those contexts they needed no methodical trials to demonstrate their impact.

These lifesaving drugs with obvious effects have stuck in our minds as models for what medical treatments are like. That's unfortunate, since it misleads us badly about the nature of most therapies.

Consider the very next antibiotic to come along: streptomycin. It was the first drug that directly treated tuberculosis (TB), then still a plague even in the developed world. Used in people whose TB was infecting their brains, streptomycin was a miracle cure. Give it and many lived; hold it back and almost all died. But tuberculous meningitis was unusual. Mostly TB infected the lungs, and many people with pulmonary tuberculosis recovered spontaneously. Streptomycin also had obvious side effects. George Orwell took it and wrote of waking up each morning to find his lips had blistered and bled, leaving him unable to open his mouth until he had washed away the dried blood sealing it. "I suppose with all these drugs," wrote Orwell, about balancing a drug's harms with its benefits, "it's rather a case of sinking the ship to get rid of the rats."

Unaided powers of observation are faulty even when it comes to detecting miracle cures—that suspicious term itself should remind us of that. Certainly for assessing moderate interventions, what are needed are structured experiments that replace intuition with protocols. That's a trade-off we dislike. The British physician John Crofton was a pioneer, one of those involved in the first reported randomized controlled trial of the modern era, that of streptomycin

in pulmonary TB. He wrote afterwards of his sense of the trial's vast historical importance and also of his own disappointment with it. Despite their importance in being able to reliably figure out what works, he concluded, such trials were dull. They were boring. They simply weren't intellectually challenging.

Crofton was right, and about something that explains a great deal that is otherwise odd in human history. There is a raw attraction when it comes to forming our own opinions about the natural world, and it has such power it stops us from being colder, more calculating, and more methodical. For a fine example, see Philadelphia in 1790s, when it was the largest city in the United States. In 1793 Philadelphians were ravaged by yellow fever. Almost one in ten died and nearly half the city's residents fled; the horror was on an Old Testament scale. Among those who stayed were two men who shared a sense of idealism, a fund of bravery, and a deep commitment to making the world a better place.

U.S. NATIONAL LIBRARY OF MEDICINE, HISTORY OF MEDICINE DIVISION

Depicted on his deathbed in 1799, George Washington is surrounded by members of his household as he succumbs to a dangerous throat infection, his death likely hastened if not caused by excessive bloodletting. In this lithograph, based on an 1851 oil painting by Junius Brutus Stearns, Washington issues final instructions to his personal secretary, Tobias Lear, who holds his hand, while his physician James Craik stands by.

William Cobbett, an English radical and patriot, had campaigned in his home country for greater democracy and less corruption—with the result that he needed to flee. He arrived in Philadelphia in 1792 and there continued his campaigns. They included, among other things, devout support for the British monarchy. Remarkably, and in a testament to contemporary open-mindedness and a sense of common heritage, he prospered. From 1797 to 1800 he published his viciously partisan *Porcupine's Gazette.*

The other personage was the city's greatest physician, Benjamin Rush, one of the signers of the Declaration of Independence. By becoming a Founding Father, Rush had already risked his life for his beliefs. During the epidemic, he not only stayed in the city, he also sought out and tended the sickest while desperately trying to work out how best to help. The genteel nostrums of the Old World, he rapidly decided, were inadequate. Something better was needed. "Bold humanity," he declared, ". . . dictates the use of powerful but painful remedies, in violent diseases." University of Michigan historian Martin S. Pernick has summarized Rush's point of view pungently: "Americans were tougher than Europeans; American diseases were correspondingly tougher than mild European diseases; to cure Americans would require uniquely powerful doses administered by heroic American physicians."

Rush certainly had the spirit for heroism, and he believed he knew what needed doing: bloodletting, on a vast scale. "I preferred frequent and small, to large bleedings, in the beginning [of the outbreak]; but towards the height and close of the epidemic, I saw no inconvenience from the loss of a pint, and even twenty ounces of blood at a time. I drew from many persons seventy and eighty ounces in five days; and from a few, a much larger quantity." For those unused to measuring their blood in ounces, the clue comes in the fact that the first measure Rush used—the smallest— was a pint. By "eighty ounces in five days," he was talking about dropping half or more of a person's blood onto the floor beside them. He soaked the ground around his house in gore. "Never before did I experience such a sublime joy," he declared, "as I now felt in contemplating the success of my remedies." He could see, as so many before and since, that bloodletting saved lives.

Cobbett believed otherwise, with just as much confidence. When yellow fever became epidemic again in 1797, he dreaded a resurgence of Rush's practices and set out to attack and ridicule the doctor and his followers in the *Porcupine Gazette.* Cobbett's campaign found its mark;

as he later wrote, "Men could not be persuaded, even by the smooth tongue of Rush, that bleeding *almost to death* was likely to save a life." To defend his reputation, however, Rush initiated a court case for libel.

The courts were still considering the suit in the winter of 1799 when the sixty-seven-year-old George Washington fell ill. He began to experience difficulties in breathing and swallowing. Physicians were sent for, but before they even arrived to tend him, Washington, a medically literate man, had himself bled by his farm's overseer, who had performed the treatment on many slaves.

His physicians thought Washington was suffering from inflammation at the back of his throat, and they were almost certainly correct. They did everything they could. They bled him once more and they blistered him. They gave him drugs to make him vomit and defecate—evacuation was still popular—and then they bled him again. They noticed, toward the end, that when they opened a vein the blood didn't so much pour out as oozed. That was because they'd removed so much of it—most of what Washington possessed—but they knew that. Their willingness to act was not based on silliness or any ignorance of physiology but on a complete conviction that bleeding was the best thing to do.

On the day Washington died, from the treatment more than the disease, Rush won his libel case. Cobbett was landed with a record sum in settlement. He fled once more, this time back to Britain.

What misled Rush was the intellectual intoxication of his argument, the faith he put in his own observations, intuitions, and theories. Those same attractions misled Cobbett. He happened to be correct about the harms of bleeding, but he was no more willing to test his beliefs with clinical experiments than his opponent. Both men believed that intelligence and argument were enough. As a result, neither ever stood any chance of testing their ideas or of persuading the other. History shows that good intentions need to be backed by good scientific technique, and that we don't grasp this instinctively.

I suspect that what disappointed Crofton, who was involved in the trial of streptomycin—which set the precedent for how new medical interventions are now assessed—was that it diminished the role and importance of reason. It was based on the principle that certain types of questions could not be properly answered using wisdom and experience. It replaced intellect with method, argument with experiment.

Crofton's disappointment was reasonable. Randomized, double-blind, controlled trials strip an essential glory from the world. They take decisions that would otherwise be subject to thought and argument and turn them into ones to be decided mechanically, no longer subject to the intoxicating forces of mental charisma or flashing insight. It is vital to notice how much we innately prefer theory and argument to tests and counting. It explains how bloodletting persisted as a false therapy for 2,000 years. Only with testing did we learn that it works only in a small number of settings, such as when the blood grows too thick and viscous or packed with iron. Our bias toward theorizing should prod us to think what sort of questions we might still be approaching in the wrong way today.

And who knows, maybe in fields outside of medicine, from economics to penal law, from traffic regulation to social policy, similar humility may one day be helpful.

Druin Burch, an attending physician at the John Radcliffe Hospital in Oxford, teaches physiology, medicine, and human evolution at the University of Oxford. His most recent book is Taking the Medicine: A Short History of Medicine's Beautiful Idea and Our Difficulty Swallowing It *(Chatto and Windus, 2009).*

WORD EXCHANGE

Weird Science?

In his review of *Weird Life* ["Bookshelf," 3/13], Laurence Marschall propagates the common scientific misconception that the breaking of chemical bonds releases energy when in fact the opposite is true: the breaking of chemical bonds requires energy. It is during bond formation that energy is released. For an organism to harness the energy of a chemical reaction, the amount of energy released during the formation of the chemical bonds of the products must be greater than the amount of energy used to break the necessary chemical bonds of the reactants.

Daniel Domin
Skokie, Illinois

The editors reply: Daniel Domin is correct that the statement that carbon's "double and triple bonds, . . . when broken, release energy" was in error, a result of oversimplification. The breaking of bonds in carbon compounds is a complex process that requires an input of "activation energy" to get started and ultimately releases hydrogen ions, which, when combined with oxygen, create molecules of water (H_2O). It is the formation of this new, strong bond that releases abundant energy. Meanwhile, carbon bonds strongly with oxygen to create carbon dioxide (CO_2). In an uncontrolled situation, of course, the joining of hydrogen and oxygen is explosive; organisms manage to handle those volatile materials safely.

While we're at it, we apologize for the wierd spelling of the book title in the review heading.

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CLOUD COVERAGE

Photographs by Mike Hollingshead

First you begin by looking at long-range weather models, such as the Global Forecast System (GFS), run by the United States National Weather Service, which gives you 384 hours of advance storm warning. As the date approaches, you don't get your hopes up, because fluctuation in moisture levels can scatter the most promising storm. Finally you switch to the Rapid Refresh (RAP) model for hourly weather updates, along with satellite imagery and radar scans. You pick a target, get in your car, and go! That's the strategy photographer Mike Hollingshead uses to zero in on the biggest thunderstorms of the Great Plains.

Based in Blair, Nebraska, Hollingshead chases storms primarily in "Tornado Alley," a corridor of intense and frequent storms that extends from his home state down to Texas. The most severe thunderstorm is a supercell, distinguished by a funnel of rising and rotating air known as a mesocyclone. Supercells spawn tornadoes about 50 percent of the time. Their varied structure makes for stunning images that flesh out the models and scans that meteorologists and space scientists use to understand storm behavior.

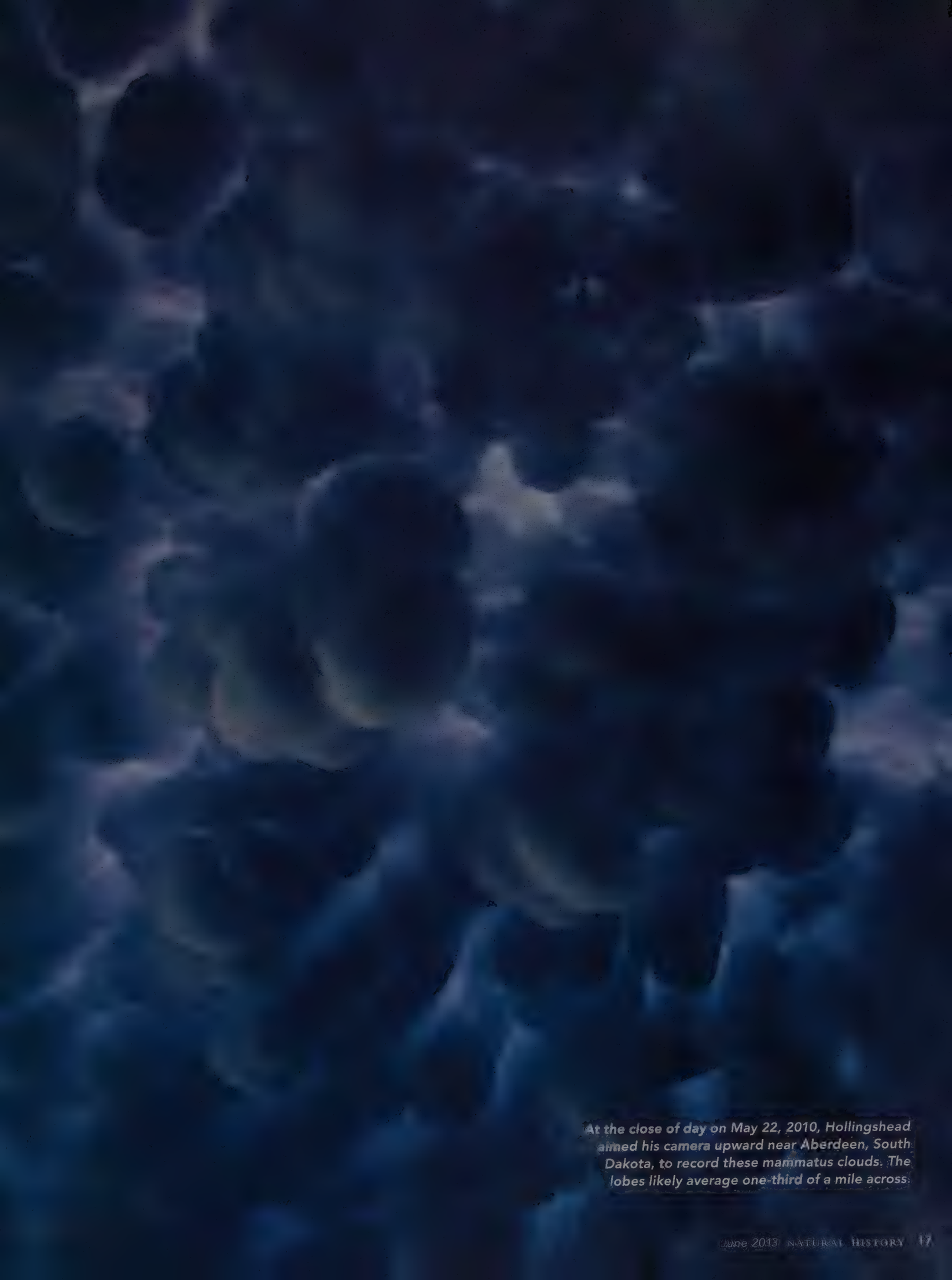
—*Erin Espelie*

Mike Hollingshead has been chasing and photographing storms since 1999. His images have been used in films, such as Take Shelter, *and published in numerous periodicals, as well as in a 2008 book chronicling seventeen of his chases. More of Hollingshead's photographs can be seen at* www.extremeinstability.com.

Hollingshead chased this supercell, or rotating thunderstorm, from Spencer to South Sioux City, Nebraska, on May 28, 2004. The setting Sun lit up a downdraft of rain. (To see some different cloud formations, turn the page.)

Recorded on the evening of June 19, 2011, this bright lightning bolt appeared above Alma, Nebraska. Hollingshead didn't have to change his location for forty minutes, as the storm stayed directly overhead.

Lightning illuminates a supercell over a truck stop in York, Nebraska, on June 17, 2009. That day Hollingshead started his chase northwest of Grand Island, Nebraska, and saw the storm "rope out" into a tornado that touched down thirty miles east in Aurora, before ending up twenty miles beyond in York.



At the close of day on May 22, 2010, Hollingshead aimed his camera upward near Aberdeen, South Dakota, to record these mammatus clouds. The lobes likely average one-third of a mile across.

Am I Blue?

IN PURSUIT OF AN EXOTIC BLOOM, A BOTANIST FALLS DOWN THE RABBIT HOLE OF COLOR THEORY.

By Rob Nicholson

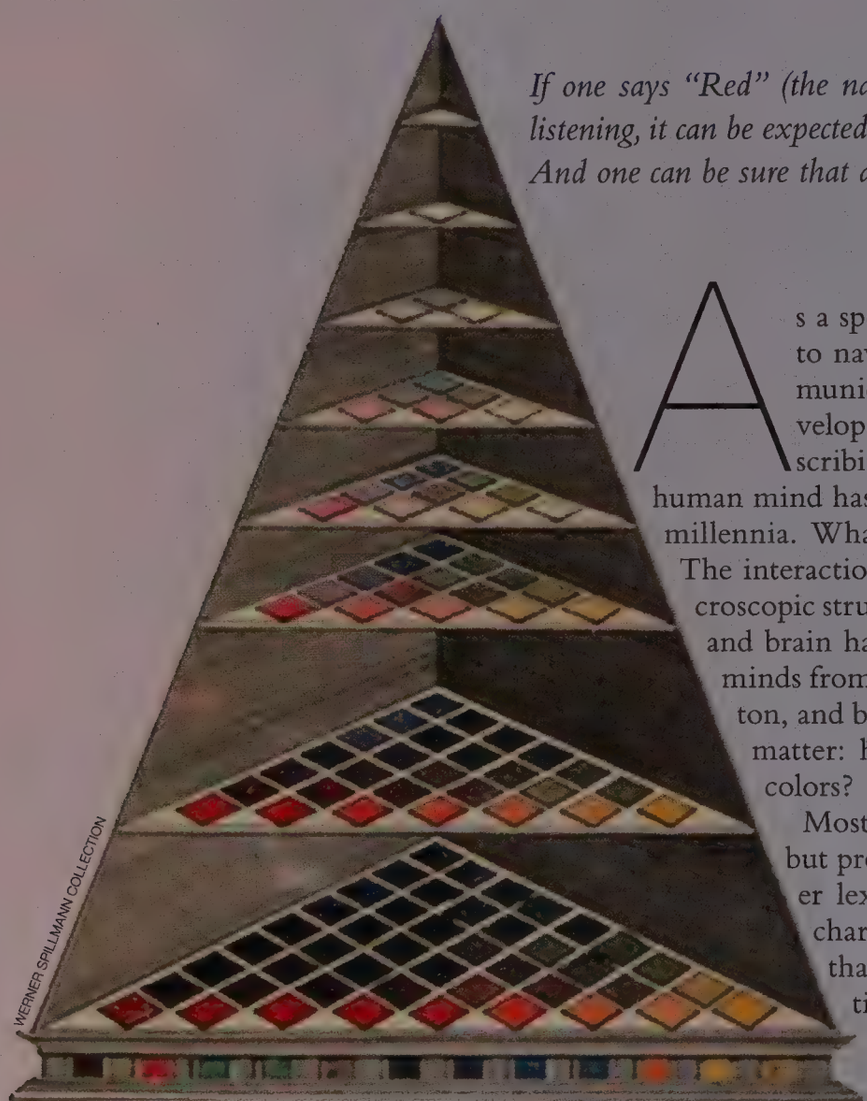


Diagram from 1772 by the Swiss mathematician, physicist, and astronomer Johann Heinrich Lambert: His was the first published arrangement of colors that conceived their interrelationships in three dimensions. Opposite page: The jade vine, Strongylodon macrobotrys, *a native of the Philippines, is a member of the pea family. Its unusual color has long intrigued the author.*

If one says "Red" (the name of a color) and there are 50 people listening, it can be expected that there will be 50 reds in their minds. And one can be sure that all these reds will be very different.

—*Josef Albers,* Interaction of Color

As a species we humans rely heavily on vision to navigate the world, and in order to communicate with those around us, we have developed a highly refined vocabulary for describing what we perceive. To that end, the human mind has wrestled with the concept of color for millennia. What is color? Where does it come from? The interaction between light, the pigments and microscopic structures of objects, and our own receptors and brain has occupied philosophical and scientific minds from Plato and Aristotle to Descartes, Newton, and beyond. But then there's a more practical matter: how do we identify, classify, and label colors?

Most of us share a basic color vocabulary, but professional color users need a much wider lexicon. The organization of colors into charts featuring agreed-upon names serves that end. As a botanist concerned with distinguishing and describing plants, I may struggle with what is meant by "cerise" or "mauve," let alone "bimini" and "puce." But color chips or swatches facilitate matching colors, whether one remembers their names or code numbers or not—and whether or not other people share one's subjective experience of a color.

Naturalists' color charts have a long history. While verbal or diagrammatic categorizations of color preceded it, perhaps the first practical chart distributed in the West was by the Englishman Richard Waller. In 1686, in the *Philosophical Transactions of the Royal Society* (of London), he published a table of 119 colors to accompany his article "A Catalogue of Simple and Mixt Colours,

with a Specimen of each Colour prefixt to its proper Name." The plate that accompanied his article accordingly had daubs of color [*see illustration below*].

Furthermore, the daubed pigments were specified in a manner that could be understood and duplicated at the time. For instance, "the Poppinjay-green is made of Blew Bice [a dark blue from "Lapis Armenius," probably azurite] and Cambodia [a brilliant orange made by evaporating the juice of a plant from the Indies], an equal weight of each. I chose Weight rather than Measure, because the heavier Colours have generally the more Body, and therefore come nearest to an Equality that way." As to his motive, Waller wrote:

> I propose to my self that this Table will be of some use and advantage in the describing of the Colours of Natural Bodies, which may be done by this Table, and represented more nearly to the Reader provided with one of the same Tables, with less ambiguity, I think, than is usual: A Standard of Colours being yet a thing wanting in Philosophy. Thus to describe a Plant, it may be seen which of the Simple or mixt Colours comes nearest to it, and then the Word affixt to that Colour may be made use of, which the Reader, if desirous, may look in his Table, and find together with the Pattern thereof.

This was a time when book illustrations, including those of plants and animals, were hand tinted, so such a reference could be a useful guide to those who had that job. But to publish such a guide was itself laborious. Indeed, even now, when color printing using a four-color, halftone screen process is sufficient for everyday purposes, in order to convey a full range of colors it is necessary to mix specialty inks from a wide variety of pigments.

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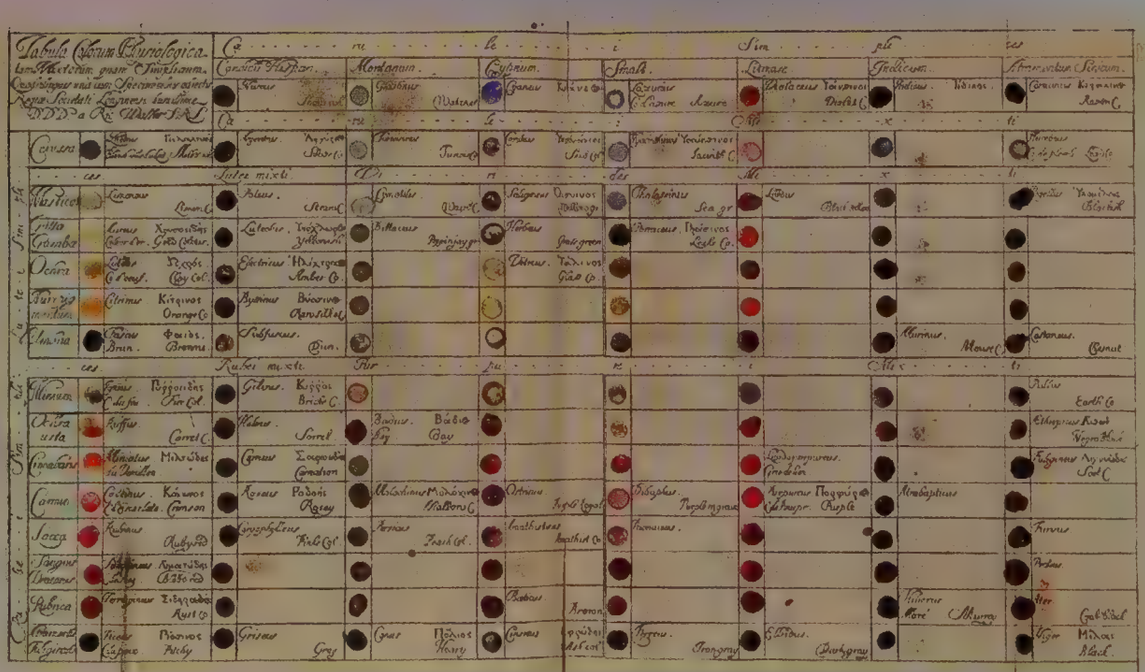
Isaac Newton, in his 1704 treatise Opticks, *presented colors as gradations in a round design.*

From the point of view of modern physics, the colors of visible light fall along a one-dimensional band of wavelengths, but various early authors used diagrams of two- and, later, three-dimensional objects (circles, squares, triangles, pyramids, cones, globes, and more) to portray relationships between colors. For example, Isaac Newton was one of the first, in his 1704 treatise *Opticks*, to conceive of presenting colors as gradients or segments of a round design [*see illustration above*]. Like many early diagrams, his was originally drawn and labeled in black and white. The first publication with hand-tinted color circles or wheels was a new, 1708 Dutch edition of a popular French manual on painting miniatures, in an essay, *Traité de la peinture en mignature*. It featured the color circles in an added essay, *Traité de la peinture en pastel* [*see illustration on oposite page*]. The author is unknown.

In *The Natural System of Colours,* ca. 1770, the English entomologist Moses Harris published more elaborate color circles [*see illustration on page 22*]. Like many before and after, including Waller, he was concerned with distinguishing primary and mixed colors:

> Here we cannot help takeing notice of the difference which nature seems to pay to the six first principal colours, viz. red, yellow, blue, which are the primitives, and orange, green, and purple, the mediates. For these are the colours with which she has decorated most of her flowers: but she seems to give the preference by far to the three first or grand primitives, and more commonly dresses the[m] in red, blue or yellow, especially those which grow naturally wild.



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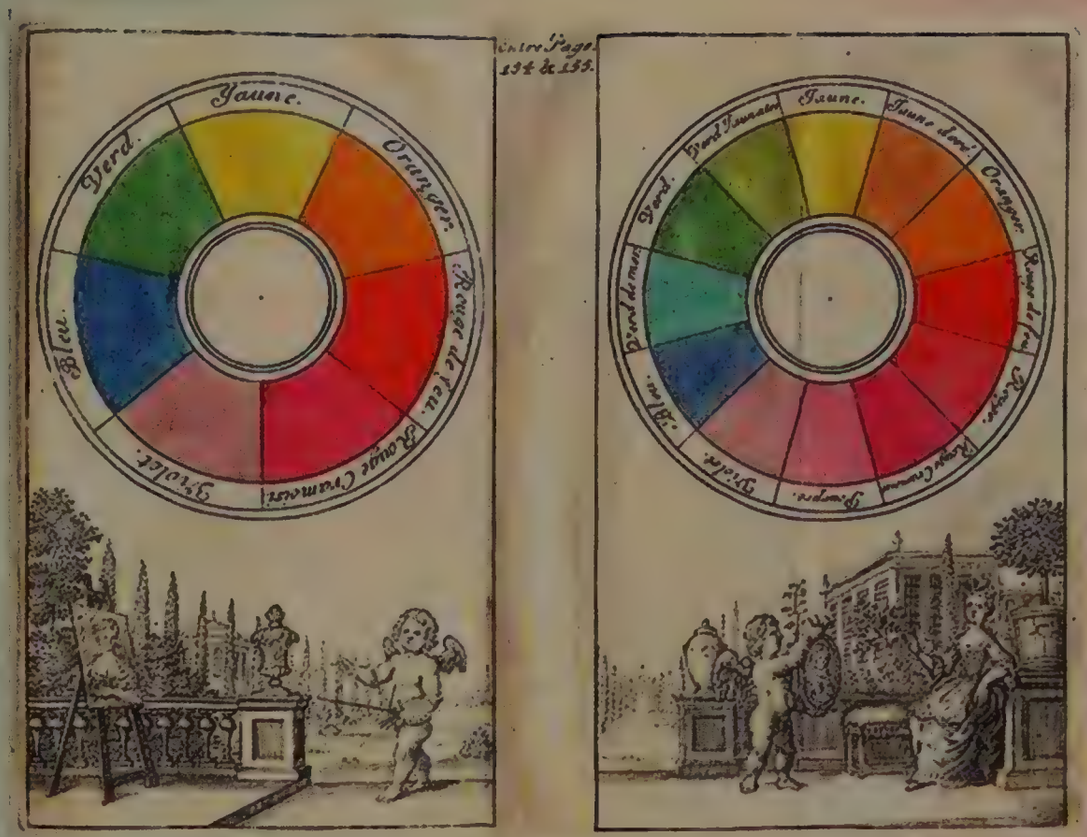
In 1686 the Englishman Richard Waller published a table with specimens of 119 colors, detailing the pigments used and the proportions for mixing them.

To convey what he meant by each color, Harris listed "some known substance, fruit or flower." For his "primitives" he referred to vermillion (mercuric sulfide, or cinnabar) and wild poppy for red; king's yellow (an arsenic sulfide) and buttercup for yellow; and ultramarine and cornflower for blue. For his mediates he gave red orpiment (another arsenic sulfide) and the common marigold for orange; sap green (made of buckthorn berries) and "lime tree" (probably linden) leaves for green; and blue bonnets and the flower of the Judas tree for purple.

Just two years later, in 1772, the Swiss mathematician, physicist, and astronomer Johann Heinrich Lambert was the first to publish an arrangement of colors un a diagram conceived in three dimensions, in this case as a pyramid [*see illustration on page 18*].



WERNER SPILLMANN COLLECTION

The first publication with hand-tinted color circles or wheels was a 1708 Dutch edition of a popular French manual on painting miniatures.

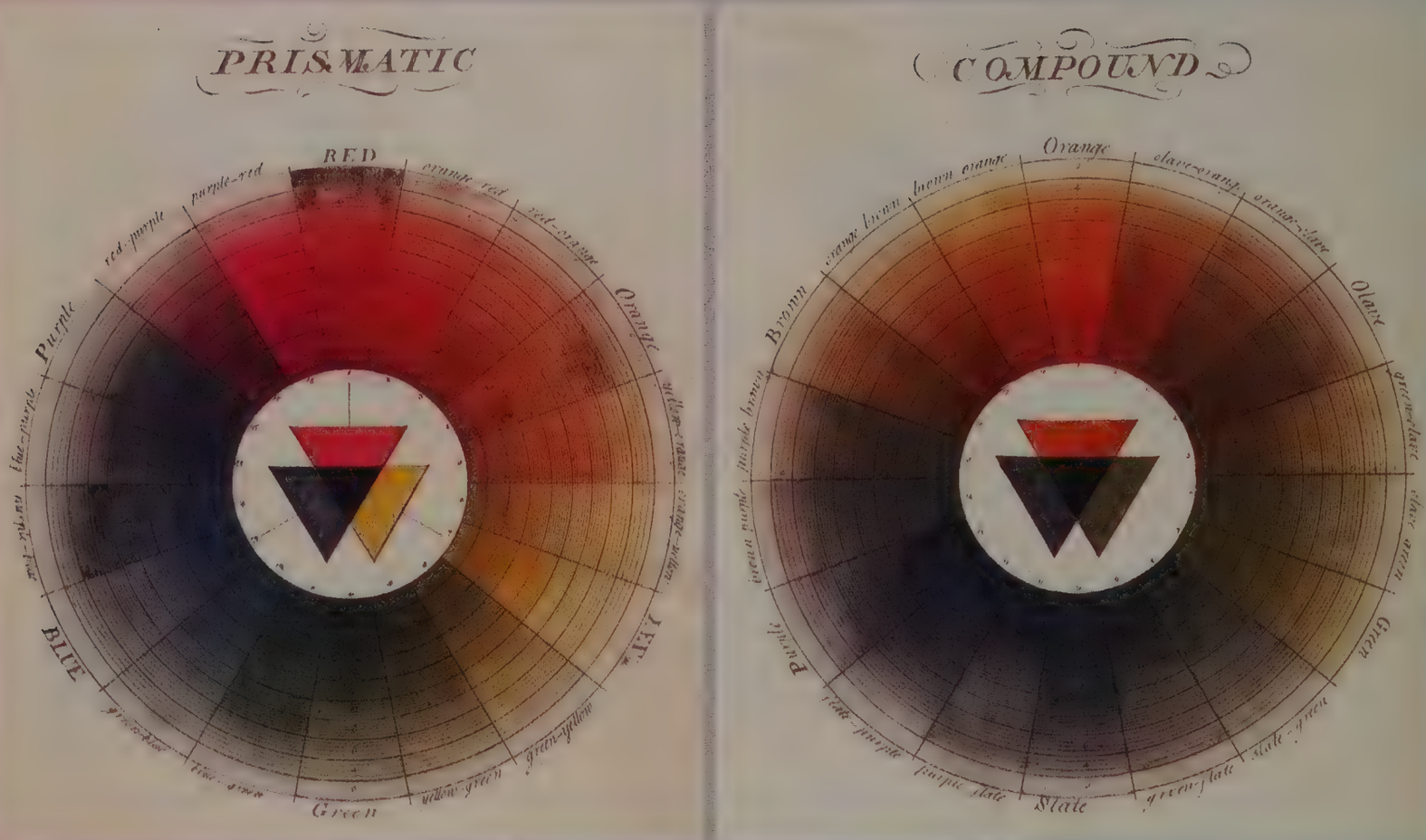
Two common color systems still in use by plant scientists include the Munsell color system, dating from 1905 with subsequent updates, and the color chart published by the Royal Horticultural Society (RHS). An artist and professor of art at what is now the Massachusetts College of Art and Design (which coincidentally my daughter attends), Albert H. Munsell arranged shades of color in three dimensions, initially as a solid sphere with a gradation of hues arranged around the circumference, values (dark to light) from the bottom to the top, and color saturation from the center to the circumference. More commonly today the system is likened to a vertical cylinder. Significantly, however, Munsell calibrated his system on the basis of increments as perceived by human subjects, and concluded that no idealized solid, such as a sphere or cylinder, could properly represent the subjective experience of color [*see illustrations on page 24*].

Around the same time, Blanche Ames Ames (both her maiden and married names), an illustrator of orchids, and her brother Adelbert, a painter, devised a chart system for mixing some 3,300 colors, many more than Munsell's, but their charts were not published [*see illustration below*]. The siblings are worth mentioning, not least because Blanche (1878–1969) was an alumna of Smith, where I teach, and indeed a true Renaissance woman—inventor, feminist, and author. Adelbert (1880–1955) went on to become a professor of physiological optics at Dartmouth and is best remembered for devising optical illusions known as the Ames Room, Ames Window, and Ames Chair.

ROBIN NICHOLSON

In horticultural and botanical circles, however, the *RHS Colour Chart* is the favored standard. This system grew out of the establishment, in 1931, of the British Colour Council (BCC), which was concerned with creating indexes of named colors for reference by government, industry, agriculture, academia, and so on. In collaboration with the Royal Horti-

A hand-mixed chart of 3,300 colors, a part of which is shown here, is preserved in the mansion once occupied by Oakes Ames and his wife, Blanche Ames Ames. Along with her brother Adelbert Ames, Blanche devised the chart in the early 1900s. The mansion and its extensive grounds are now preserved as the Borderland Historic District near Easton, Massachusetts.



WERNER SPILLMANN COLLECTION

In about 1770, the English entomologist Moses Harris published two color wheels, one of primary colors (red, yellow, and blue) and their mixtures, and another based on the intermediate colors orange, green, and violet. Harris was the author of several books on insects, for which he engraved and colored his own illustrations.

cultural Society, between 1938 and 1941, the BCC produced the *Horticultural Colour Chart* in two volumes, with 800 colors. According to Brent Elliot, the RHS historian and author of *The Royal Horticultural Society: A History 1804–2004,* the colors were printed by a screen process, arranged four to a page. Then, in 1958, the RHS decided to devise a new chart, arranging the colors on strips fastened together in four fans, for a total of 792 samples. Each color was mixed separately, and most were printed in solid color, except where a half-tone screen was needed to obtain sufficient brightness.

The new chart was issued in 1966. Writes Elliott: "One major change was the elimination of colour names—canary yellow, Doge purple—in favour of simple numbers—Red 41A, Blue-Green 119C. 'I am desolate that the old names have disappeared and to see that the scientists are taking over from the poets,' said Fred Whitsey [the gardening correspondent for *The Sunday Telegraph*], but otherwise the new Colour Chart was a great success." This was the predecessor to later, expanded editions; the most recent, produced in 2007, has a total of 896 colors. The strength of this resource lies in its practicality and adaptation to purpose. The leaves of the four fans are numbered, and each bears four color swatches, identified as A, B, C, or D. Each color swatch even has a porthole that can be laid over an object to facilitate accurate matches. A flower described seventy-five years ago with the RHS color system could be accurately depicted by an artist today using the same resource. Although, like the *Munsell Book of Color,* it is an expensive item, it has long been recognized as the authoritative reference work for rendering accurate descriptions of botanical color [*see illustration on page 26*].

We do occasionally find a flower that challenges our view of the world. Sometimes a blossom has petals or portions of petals so unusual that we struggle to pinpoint their color. The jade vine, *Strongylodon macrobotrys,* is one such flower. A rampant and vigorous vine, it is a wisteria of the tropics, and like species in the closley related genus *Wisteria,* it is a member of the pea family, the Fabaceae. The flowers are borne on racemes, which are unbranched clusters of a variable number of flowers, each flower on its own stalk. As in wisteria, the racemes hang down from the vine.

The blue-green color of the blossoms is nearly impossible to describe in simple terms. "Jade" seem too broad, because jade, the gemstone, comes in many colors, as does turquoise, another stone of similar pigmentation. Hydrated chromium oxide, a bright blue-green pigment, is quite close in color, but how many people are famil-

iar with that mineral? Only a few other flowers display similar tones. Three that are comparable share the word "viridian" in their formal names: *Lachenalia viridiflora* (of the asparagus family, Asparagaceae) and *Ixia viridiflora* (of the iris family, Iridaceae), both South African bulb species; and the shrub *Ecbolium viride* (of the acanthus family, Acanthaceae), native to India and Malaysia.

There are about a dozen species of shrubs and vines in the genus *Strongylodon*. Hawaii's *S. ruber* has lovely chains of crimson flowers that have been woven into leis. The local name, *nuku `i`iwi,* means "beak of the *`i`iwi,*" and indeed each curved bloom recalls the beak of that native, red-feathered bird with its curved bill. From Hawaii, *Strongylodon* is distributed westward across Southeast Asia to Madagascar. These are plants of wet tropical forests, and, though highly ornamental, are relatively rare in the gardens of the world.

The islands of the Philippines have about seven species, many of which occur nowhere else. *S. macrobotrys* is the most famous of this group, first collected by botanists in 1854, when scientists of the United States Exploring Expedition (also known as the Wilkes Expedition) discovered it on Mount Makiling on Luzon. In 1919 William H. Brown, a botanist at the University of the Philippines, did an extensive survey of the same mountain and reported that the jade vine grew in a moist tropical forest between about 1,000 and 2,000 feet, but that the racemes were not frequently apparent.

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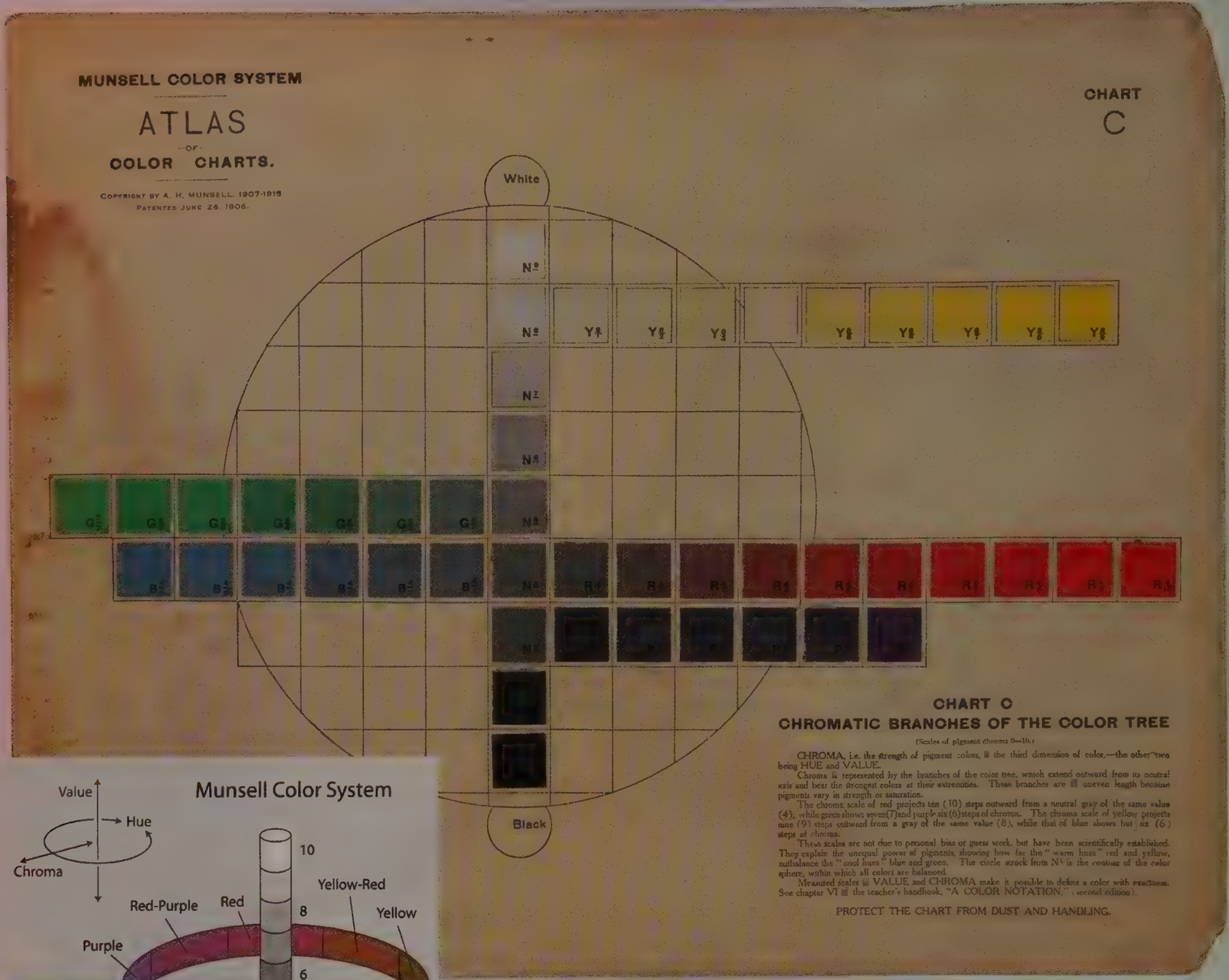
A plate from Harris's An Exposition of English Insects *(1782)*

In its native haunts of the Philippines islands of Luzon, Mindoro, and Catanduanes, *S. macrobotrys* is a rampant liana known as *tayabak* or *bayou*. Lianas are thick-stemmed tropical vines that snake through the understory to the tops of the canopy, clasping and twining around forest trees until they break through to the sunlight. The jade vine has a compound leaf of three glossy deep-green leaflets; if it wasn't in bloom you might machete your way through it without a second thought. The clearing of large tracts of Philippine forest has reduced the abundance of the jade vine, because the habitat it is attuned to has been greatly reduced. Philippine botanists consider it threatened and are studying its seed reproduction. Propagation of the plants has been mostly accomplished by means of cuttings, and seeds are reputed to be viable for a few weeks only.

In 1998, Christina J. Prychid and colleagues at the Royal Botanic Gardens, Kew, reported they were successful in getting only 1.27 percent of 316 hand-pollinated flowers to set fruit. Their work showed that their specimen was self-sterile, and probably the species as a whole is largely so. In the wild the species' natural pollinators—believed to be nectar-feeding bats—would carry pollen from one



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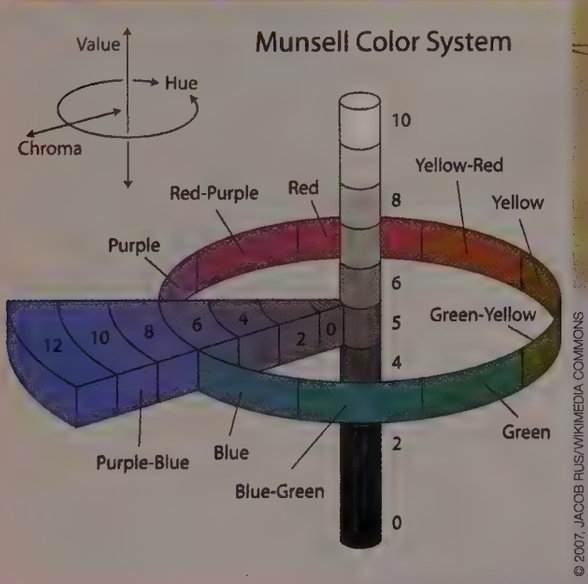

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A. H. MUNSELL, A COLOR NOTATION/PROJECT GUTENBERG

Beginning around the turn of the twentieth century, Albert H. Munsell arranged shades of color in three dimensions, initially as a solid sphere, right, with a gradation of hues (red, green, and so on) around the circumference, values (dark to light) from the bottom to the top, and chroma (saturation or intensity) increasing from the vertical axis to the surface. He later concluded that when colors are calibrated subjectively, the increments of hue, value, and chroma would not fit such an idealized solid. Accordingly, at top, one of his early charts shows that in terms of chroma, the branches of the main hues differ in length, "because pigments vary in strength or saturation." Above: A cylindrical diagram illustrates the notation for hues at value 5, chroma 6, with a detail of the chromas of purple-blue from 0 to 12. The Munsell system is now a widely used resource with more than 1,600 colors in book format.

plant to another. The blooms glow attractively at dusk, when bats are on the wing.

In 1999, Tatsuo Konishi, director of the Tsukuba Botanic Garden in Japan, reported hand pollinating flowers and finding variation in the flower color of the fifteen resulting plants: "three darker, eight similar and four fainter" compared with the mother plant. More recently, in 2010, again using the Tsukuba Botanic Garden plant, Japanese researchers teased apart the pigments within the flowers and found the main pigments to be malvin (an anthocyanin pigment) and saponarin (a flavone glucoside pigment) in a 1:9 ratio. It is the interaction of the two pigments, at a particular, slightly alkaline pH of the sap, that lends the blossom its strikingly famous color.

Once *Strongylodon* reaches a certain point of maturity, usually with stems as thick as your thumb, it sends forth racemes that hang down three feet, with upwards of 165 individual flowers per raceme. The flowers are the typical pea flower configuration, with an upward-arching petal called a "banner," two lower arching petals called "keels," and a pair of reduced petals in the middle termed "wings."

MAURIZIO VECCHIA

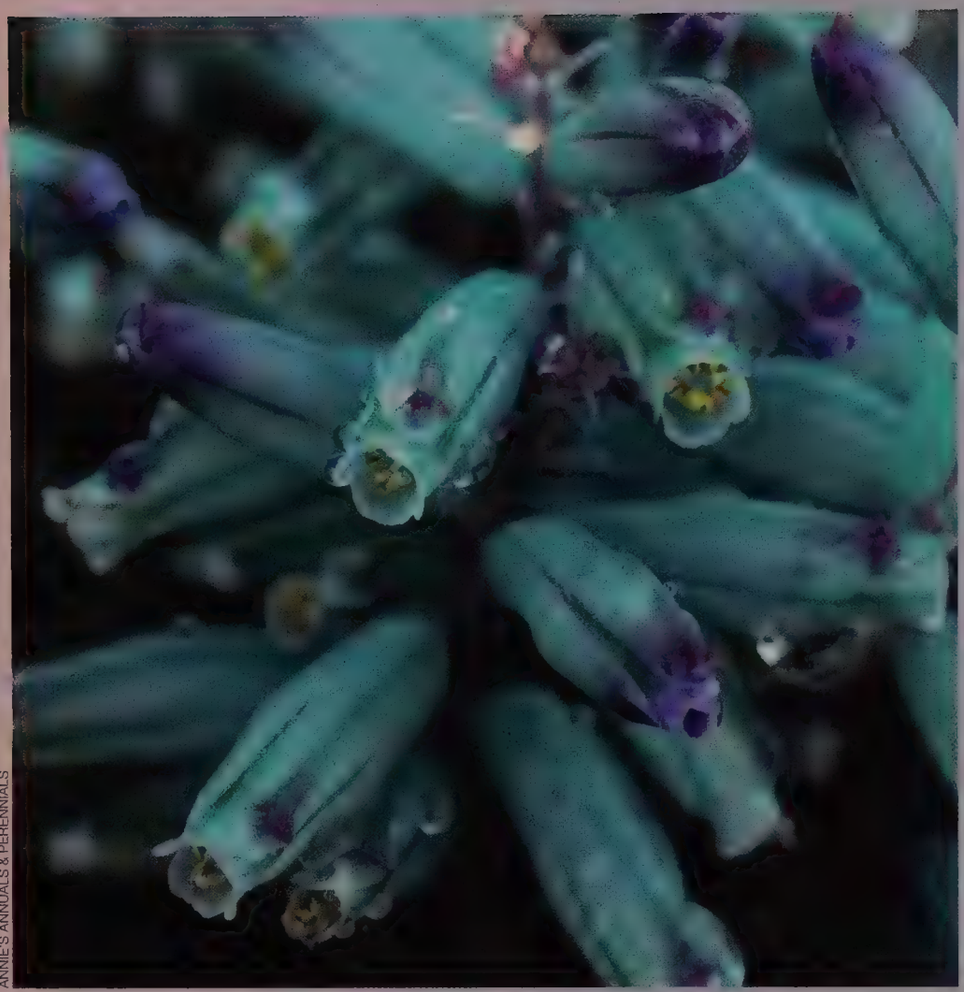
Ixia viridiflora, *a South African member of the iris family, has a color similar to that of the jade vine.*

My closest brush with *Strongylodon macrobotrys* in the field occurred during a 1993 trip to the island of Mindanao. I went to collect plants for the National Cancer Institute with my colleague Melvin Shemluck, a botanist and biochemist from Quinsigamound Community College in Worcester, Massachusetts. Along with collaborating Philippine botanists, we climbed from Kidapawan (elevation 920 feet) to Lake Venado at 7,200 feet, a five-hour hike through tropical forests and along steep, muddy trails. The next day we ascended the peak of 9,691-foot Mount Apo, and on the upper flanks of the mountain we collected the rare *Taxus sumatrana* (Chinese yew) that was our primary quarry. At the time, after years of testing, Taxol, the drug derived from research on the Pacific yew, had just been approved by the FDA for the treatment of ovarian cancer. This was one of many trips I made to collect rare *Taxus* species worldwide [*see "Death and Taxus," September 1992*].

We started back the next day. Our worst fear, monsoons, came true with a vengeance that morning, and the trickle of a stream we had crossed nine times was now a swirling two-foot deep torrent. We struggled throughout the day, and during one portage, Shemluck lost his footing and began to be swept away in the current. One of our porters, a sinewy old man, grabbed hold of a branch to anchor himself, lunged toward Shemluck, and caught him by his collar as he sped by.

A few hours later, as we were descending the mountain and making small talk, our Philippine host asked if there were any other plants in the Philippines I wished to find. When I replied that I would really like to see the jade vine, it stopped him short. "Oh," he replied with some hesitation, "we passed that species two hours ago." Most likely, in retrospect, he was referring to another species of *Strongylodon,* but in any case, backtracking was inconceivable, and we trudged along through the muddy jungle, me with a botanical version of a fish story about "the one that got away."

Shemluck and I finally got to see the species flowering in the Enid A. Haupt Conservatory of the New York Botanical Garden, and from that plant we obtained a few cuttings for the Botanic Garden of Smith College in July of 1999. Once the cuttings rooted and the plants were of sufficient size, they were planted in the ground at the gar-



ANNIE'S ANNUALS & PERENNIALS

NATHAN YUEN/HAWAIANFOREST.COM

den's Palm House and trained over a newly constructed arbor. For five years they behaved like prima donnas who wouldn't sing—lots of twining, high-maintenance vegetation to continually primp and prune, but no aria of flowers.

Anecdotal accounts on the Internet stated that flowering only occurred when basal trunks were at least half an inch thick. By 2009 the plants at Smith had long since surpassed that girth, and I dared hope to get results. Flowering period in the Philippines is from March to June, but it was still startling to finally find, in mid-March, a single raceme starting to descend from the top of the arbor.

I brought a blossom over to our science library and compared it to the charts in our edition of the *Munsell Book of Color,* then totaling 1,150 colors. The lower keels of the flowers matched with colors 10G 7/6, 7.5G 7/6, and 2.5 G 7/6, as there was gradation within the keel. The banner, the upper petal, was to my eye between 10G 7/4 and 10G 8/4, while there was a slight bit of very dark blue on the edge of the wings that keyed to 5BG 4/8. Munsell felt assigning color names to his swatches was arbitrary, "foolish," and "misleading," but because of his decision to omit names one can only get a sense of the described object with Munsell's charts in hand.

Since Smith's botanic garden does not own a copy of the *RHS Colour Chart* (donation opportunity!), I brought a small plastic bag of flowers over to the library at the University of Massachusetts Amherst, which has a copy (including a booklet cross-referencing some color names). After sifting for a half hour and matching colors, I could offer, to my knowledge, the first "numerically accurate" description of the jade vine's flowers, at least as grown at the Botanic Garden of Smith College. The keel portion of the flower was close to 124C, Jade Green, and 128C, Viridian Green, but to my eye and in the light I was

Lachenalia viridiflora, top photograph, a South African member of the asparagus family, has a color similar to that of the jade vine but is not a close relative, whereas Hawaii's strongly contrasting Strongylodon ruber, *bottom, shares the jade vine's genus.*

A botanist compares the RHS Colour Chart fan of purple shades to blossoms of Heterocentron elegans, *or Spanish shawl, a plant native to Mexico and Central America.*

MARK PFEFFER/THE NEW YORK BOTANICAL GARDEN AND MERTZ LIBRARY

in (under fluorescent light but close to a window), the best match was 133D, a color that bore no name in the booklet. The banner was closest to the unnamed 133C, while the dark edge of the wing was the unnamed 102A.

So what color *is* it? Blue? Blue-green? It ultimately depends upon what matching system you use, your own eyes and light conditions, even your own (and your culture's) categorization of colors. Color, as always, just gets more elusive the harder you try to grasp it.

Is it blue? The very question brings to mind a classic moment in American cinema from the movie *To Have and Have Not* (1944). A breezy Hoagy Carmichael floats out a vocal and is joined by the impossibly beautiful Lauren Bacall. They croon together a song titled "Am I Blue?"

To be sure, the lyrics speak of unrequited love, but they also speak to me of a horticultural desire to answer a question, after years of waiting, about the barely describable blueness of the incredible jade vine flower of the Philippines.

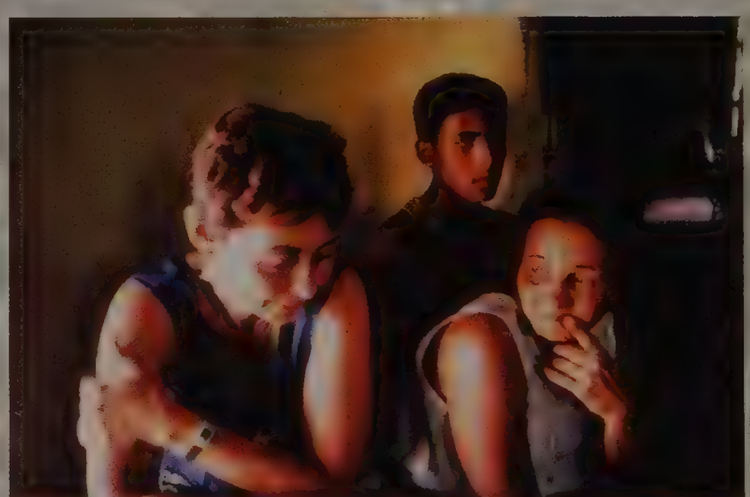
A version of this story appeared in Botanic Garden News, *Spring 2009, published by the Botanic Garden of Smith College.*

Rob Nicholson has worked in New England botanic gardens (the Arnold Arboretum of Harvard University and the Botanic Garden of Smith College) for the past thirty-six years. He has conducted more than thirty plant-collecting trips in the United States and other nations in search of rare and unusual plants, often with research collaborator Melvin Shemluck. While many of their targeted species had medicinal, conservation, or research value, Nicholson states that "plant hunting dates from before humans could first be termed human, and it continues today, though now more people search for plants via computer. When I read about foraging as a 'new trend' in foodie circles, it just seems like a return to the most basic human activity."

No More Angel Babies on the Alto do Cruzeiro

A DISPATCH FROM BRAZIL'S REVOLUTION IN CHILD SURVIVAL

By Nancy Scheper-Hughes



DANIEL HOFFMAN

In 1993, on the Alto do Cruzeiro, a shantytown in Brazil's municipality of Timbaúba, the author (left) converses with Lourdes (right), one of her key informants. They recall the death a few years earlier of Lourdes's favorite son, "Zezinho," who was gunned down by a rival and left to die in a pile of garbage. Lourdes almost "let Ze go" when he was an infant, because he seemed unlikely to survive. Ze grew up strong and became her "arms and legs," her main support in life, only to be cruelly taken away.

It was almost fifty years ago that I first walked to the top of the Alto do Cruzeiro (the Hill of the Crucifix) in Timbaúba, a sugar-belt town in the state of Pernambuco, in Northeast Brazil. I was looking for the small mud hut, nestled in a cliff, where I was to live. It was December 1964, nine months after the coup that toppled the left-leaning president, João Goulart. Church bells were ringing, and I asked the woman who was to host me as a Peace Corps volunteer why they seemed to ring at all hours of the day. "Oh, it's nothing," she told me. "Just another little angel gone to heaven."

That day marked the beginning of my life's work. Since then, I've experienced something between an obsession, a trauma, and a romance with the shantytown. Residents of the newly occupied hillside were refugees from the military junta's violent attacks on the peasant league movement that had tried to enforce existing laws protecting the local sugarcane cutters. The settlers had thrown together huts made of straw, mud, and sticks, or, lacking that, lean-tos made of tin, cardboard, and scrap materials. They had thrown together families in the same makeshift fashion, taking whatever was at hand and making do. In the absence of husbands, weekend play fathers did nicely as long as they brought home the current baby's powdered milk, if not the bacon. Households were temporary; in such poverty women were the only stable force, and babies and fathers were circulated among them. A man who could not provide support would be banished to take up residence with another, even more desperate woman; excess infants and babies were often rescued by older women, who took them in as informal foster children.

Premature death was an everyday occurrence in a shantytown lacking water, electricity, and sanitation and beset with food scarcity, epidemics, and police violence. My assignment was to immunize children, educate midwives, attend births, treat infections, bind up festering wounds, and visit mothers and newborns at home to monitor their health and refer them as needed to the district health post or to the emergency room of the private hospital—owned by the mayor's brother—where charity cases were sometimes attended, depending on the state of local patron-client relations.

I spent several months making the rounds between the miserable huts on the Alto with a public-health medical kit strapped on my shoulder. Its contents were pathetic: a bar of soap, scissors, antiseptics, aspirin, bandages, a glass syringe, some ampules of vaccine, several needles, and a pumice stone to sharpen the needles, which were used over and over again for immunizations. Children ran away when they saw me coming, and well they might have.

But what haunted me then, in addition to my own incompetence, was something I did not have the skill or maturity to understand: Why didn't the women of the Alto grieve over the deaths of their babies? I tucked that question away. But as Winnicott, the British child psychoanalyst, liked to say, "Nothing is ever forgotten."

NANCY SCHEPER-HUGHES

A mother and her children in the 1980s: Because of inadequate nutrition, medical care, and sanitation in the shantytown, many babies died in infancy, end even the survivors often exhibited stunting. Mothers avoided breastfeeding because they felt it depleted their own strength; they relied instead on powdered milk, a poor substitute.

Sixteen years elapsed before I was able to return to the Alto do Cruzeiro, this time as a medical anthropologist. It was in 1982—during the period known as the *abertura*, or opening, the beginning of the end of the military dictatorship—that I made the first of the four trips that formed the basis for my 1992 book, *Death Without Weeping: The Violence of Everyday Life in Brazil*. My goal was to study women's lives, specifically mother love and child death under conditions so dire that the Uruguayan writer Eduardo Galeano once described the region as a concentration camp for 30 million people. It was not a gross exaggeration. Decades of nutritional studies of sugarcane cutters and their families in Pernambuco showed hard evidence of slow starvation and stunting. These nutritional dwarfs were surviving on a daily caloric intake similar to that of the inmates of the Buchenwald concentration camp. Life on the Alto resembled prison-camp culture, with a moral ethic based on triage and survival.

If mother love is the cultural expression of what many attachment theorists believe to be a bioevolutionary script, what could this script mean to women living in these conditions? In my sample of three generations of mothers in the sugar plantation zone of Pernambuco, the average woman had 9.5 pregnancies, 8 live births, and 3.5 infant deaths. Such high rates of births and deaths are typical of societies that have not undergone what population experts call the demographic transition, associated with economic development, in which first death rates and, later, birth rates drop as parents begin to trust that more of their infants will survive. On the contrary, the high expectation of loss and the normalization of infant death was a powerful conditioner of the degree of maternal attachments. Mothers and infants could also be rivals for scarce resources. Alto mothers renounced breastfeeding as impossible, as sapping far too much strength from their own "wrecked" bodies.

Scarcity made mother love a fragile emotion, postponed until the newborn displayed a will to live—a taste (*gusto*) and a knack (*jeito*) for life. A high expectancy of death prepared mothers to "let go" of and to hasten the death of babies that were failing to thrive, by reducing the already insufficient food, water, and care. The "angel babies" of the Alto were neither of this Earth nor yet fully spirits. In appearance they were ghostlike: pale and wispy-haired; their arms and legs stripped of flesh; their bellies grossly distended; their eyes blank and staring; their faces wizened, a cross between startled primate and wise old sorcerer.

The experience of too much loss, too much death, led to a kind of patient resignation that some clinical psychologists might label "emotional numbing" or the symptoms of a "masked depression." But the mothers' resignation was neither pathological nor abnormal. Moreover, it was a moral code. Not only had a continual exposure to trauma obliterated rage and protest, it also minimized attachment so as to diminish sorrow.

Infant death was so commonplace that I recall a birth-

NANCY SCHEPER-HUGHES

Before the demographic transition to lower death and birth rates, death came at any age in the municipality of Timbaúba. For many years, free plywood and cardboard coffins, like these standing at the ready in 1987 in the woodworking shop behind the town hall, were provided to the poor by the mayor's office.

day party for a four-year-old in which the birthday cake, decorated with candles, was placed on the kitchen table next to the tiny blue cardboard coffin of the child's nine-month-old sibling, who had died during the night. Next to the coffin a single vigil candle was lit. Despite the tragedy, the child's mother wanted to go ahead with the party. "*Parabéns para você*," we sang, clapping our hands. "Congratulations to you!" the Brazilian birthday song goes. And on the Alto it had special resonance: "Congratulations, you survivor you—you lived to see another year!"

When Alto mothers cried, they cried for themselves, for those left behind to continue the struggle. But they cried the hardest for their children who had almost died, but who surprised everyone by surviving against the odds. Wiping a stray tear from her eye, an Alto mother would speak with deep emotion of the child who, given up for dead, suddenly beat death back, displaying a fierce desire for life. These tough and stubborn children were loved above all others.

Staying alive in the shantytown demanded a kind of egoism that often pits individuals against each other and rewards those who take advantage of those weaker than themselves. People admired toughness and strength; they took pride in babies or adults who were cunning and foxy. The toddler that was wild and fierce was preferred to the quiet and obedient child. Men and women with seductive charm, who could manipulate those around them, were better off than those who were kind. Poverty doesn't ennoble people, and I came to appreciate what it took to stay alive.

Theirs were moral choices that no person should be forced to make. But the result was that infants were viewed as limitless. There was a kind of magical replaceability about them, similar to what one might find on a battlefield. As one soldier falls, another takes his place. This kind of detached maternal thinking allowed the die-offs of shantytown babies—in some years, as many as 40 percent of all the infants born on the Alto died—to pass without shock or profound grief. A woman who had lost half her babies told me, "Who could bear it, Nancí, if we are mistaken in believing that God takes our infants to save us from pain? If that is not true, then God is a cannibal. And if our little angels are not in heaven flying around the throne of Our Lady, then where are they, and who is to blame for their deaths?"

If mothers allowed themselves to be attached to each newborn, how could they ever live through their babies' short lives and deaths and still have the stamina to get pregnant and give birth again and again? It wasn't that Alto mothers did not experience mother love at all. They did, and with great intensity. But mother love emerged as their children developed strength and vitality. The apex of mother love was not the image of Mary and her infant son, but a mature Mary, grieving the death of her young adult son. The Pietà, not the young mother at the crèche, was the symbol of motherhood and mother love on the Alto.

In *Death Without Weeping* I first told of a clandestine extermination group that had begun to operate in Timbaúba in the 1980s. The rise of these vigilantes seemed paradoxical, insofar as it coincided with the end of the twenty-year military dictatorship. What was the relationship between democracy and death squads? No one knew who was behind the extrajudicial *limpeza* ("street cleaning," as their supporters called it) that was targeting "dirty" street children and poor young Black men from the shantytowns. But by 2000 the public was well aware of the group and the identity of its leader, Abdoral Gonçalves Queiroz. Known as the "Guardian Angels," they were responsible for killing more than 100 victims. In 2001 I was invited, along with my husband,

to return to Timbaúba to help a newly appointed and tough-minded judge and state prosecutor to identify those victims whose relatives had not come forward. In the interim, the death squad group had infiltrated the town council, the mayor's office, and the justice system. But eleven of them, including their semiliterate gangster-boss, Queiroz, had been arrested and were going on trial.

The death squad was a residue of the old military regime. For twenty years, the military police had kept the social classes segregated, with "dangerous" street youths and unemployed rural men confined to the hillside slums or in detention. When the old policing structures loosened following the democratic transition, the shantytowns ruptured and poor people, especially unemployed young men and street children, flooded downtown streets and public squares, once the preserve of *gente fina* (the cultivated people). Their new visibility betrayed the illusion of Brazilian modernity and evoked contradictory emotions of fear, aversion, pity, and anger.

Excluded and reviled, unemployed Black youths and loose street kids of Timbaúba were prime targets of Queiroz and his gang. Depending on one's social class and politics, the band could be seen as hired serial killers or as *justiceiros* (outlaw heroes) who were protecting the community. Prominent figures—well-known businessmen and local politicians—applauded the work of the death squad, whom they also called "Police 2," and some of these leading citizens were active in the extrajudicial "courts" that were deciding who in Timbaúba should be the next to die.

NANCY SCHEPER-HUGHES

"Não aguento mais"—"I can't take it anymore": In 2001, Irene da Silva (right) and other residents of the Alto do Cruzeiro meet to organize a public protest against a death squad that had been targeting street children and poor young Black men from the shantytowns.

During the 2001 death-squad field research expedition, I played cat-and-mouse with Dona Amantina, the dour manager of the *cartorio civil,* the official registry office. I was trying to assemble a body count of suspicious homicides that could possibly be linked to the death squad, focusing on the violent deaths of street kids and young Black men. Since members of the death squad were still at large, I did not want to make public what I was doing. At first, I implied that I was back to count infant and child deaths, as I had so many years before. Finally, I admitted that I was looking into youth homicides. The manager nodded her head. "Yes, it's sad. But," she asked with a shy smile, "haven't you noticed the changes in infant and child deaths?" Once I began to scan the record books, I was wearing a smile, too.

Brazil's national central statistics bureau, the Instituto Brasileiro de Geografia e Estatística (IBGE), began reporting data for the municipality of Timbaúba in the late 1970s. In 1977, for example, IBGE reported 761 live births in the municipality and 311 deaths of infants (up to one year of age) for that same year, yielding an infant mortality rate of 409 per 1,000. A year later, the IBGE data recorded 896 live births and 320 infant deaths, an infant mortality rate of 357 per 1,000. If reliable, those official data indicated that between 36 and 41 percent of all infants in Timbaúba died in the first twelve months of life.

During the 1980s, when I was doing the research for *Death Without Weeping,* the then mayor of Timbaúba, the late Jacques Ferreira Lima, disputed those figures. "Impossible!" he fumed "This *município* is growing, not declining." He sent me to the local private hospital built by, and named for, his father, João Ferreira Lima, to compare the IBGE statistics with the hospital's records on births

NANCY SCHEPER-HUGHES

A local community health agent makes his rounds in his section of the Alto do Cruzeiro. There are now 120 such agents working in poor communities throughout the municipality of Timbaúba.

and deaths. There, the head nurse gave me access to her records, but the official death certificates only concerned stillbirths and perinatal deaths. In the end I found that the best source of data was the ledger books of the *cartorio civil,* where births and infant and child deaths were recorded by hand. Many births were not recorded until after a child had died, in order to register a death and receive a free coffin from the mayor's office. The statistics were as grim as those of the IBGE.

In 2001, a single afternoon going over infant and toddler death certificates in the same office was enough to document that something radical had since taken place—a revolution in child survival that had begun in the 1990s. The records now showed a completed birth rate of 3.2 children per woman, and a mortality rate of 35 per 1,000 births. Subsequent field trips in 2006 and 2007 showed even further reductions. The 2009 data from the IBGE recorded a rate of 25.2 child deaths per 1,000 births for Timbaúba.

Though working on other topics in my Brazilian field trips in 2001, 2006, and 2007, I took the time to interview several young women attending a pregnancy class at a newly constructed, government-run clinic. The women I spoke with—some first-time mothers, others expecting a second or third child—were confident in their ability to give birth to a healthy baby. No one I spoke to expected to have, except by accident, more than two children. A pair—that was the goal. Today, young women of the Alto can expect to give birth to three or fewer infants and to see all of them live at least into adolescence. The old stance of maternal watchful waiting accompanied by deselection of infants viewed as having no "talent" for life had been replaced by a maternal ethos of "holding on" to every infant, each seen as likely to survive. As I had noted in the past as well, there was a preference for girl babies. Boys, women feared, could disappoint their mothers—they could kill or be killed as adolescents and young men. The Alto was still a dangerous place, and gangs, drug dealers, and the death squads were still in operation. But

NANCY SCHEPER-HUGHES

The health agent checks up on one of the 150 high-risk families for which he is responsible. Agents are the primary intermediaries between poor people and the national health care system, recording all births, deaths, and illnesses and referring the sick to health posts and hospitals.

JENNIFER S. HUGHES

Through a state-run program, free milk is distributed in the community by women who have an extra room in their homes.

women in the state-run clinic spoke of having control over their reproductive lives in ways that I could not have imagined.

By 2001 Timbaúba had experienced the demographic transition. Both infant deaths and births had declined so precipitously that it looked like a reproductive workers' strike. The numbers—though incomplete—were startling. Rather than the more than 200 annual infant and child mortalities of the early 1980s, by the late 1990s there were fewer than 50 childhood deaths recorded per year. And the causes of death were specific. In the past the causes had been stated in vague terms: "undetermined," "heart stopped, respiration stopped," "malnutrition," or the mythopoetic diagnosis of "acute infantile suffering."

On my latest return, just this June, the reproductive revolution was complete. The little two-room huts jumbled together on the back roads of the Alto were still poor, but as I visited the homes of dozens of Alto residents, sometimes accompanied by a local community health agent, sometimes dropping in for a chat unannounced, or summoned by the adult child of a former key informant of mine, I saw infants and toddlers who were plump and jolly, and mothers who were relaxed and breastfeeding toddlers as old as three years. Their babies assumed a high status in the family hierarchy, as precious little beings whose beauty and health brought honor and substance—as well as subsistence—to the household.

Manufactured cribs with pristine sheets and fluffy blankets, disposal diapers, and plastic rattles were much in evidence. Powdered milk, the number one baby killer in the past, was almost a banned substance. In contrast, no one, literally, breastfed during my early years of research on the Alto. It was breast milk that was banned, banned by the owners of the sugar plantations and by the bourgeois *patroas* (mistresses of the house) for whom the women of the Alto washed clothes and cleaned and cooked and served meals. Today, those jobs no longer exist. The sugar mills and sugar estates have closed down, and the landowning class has long since moved, leaving behind a population of working-class poor, a thin middle class (with washing machines rather than maids), and a displaced rural labor force that is largely sustained by the largesse of New Deal–style federal assistance.

Direct cash transfers are made to poor and unemployed families, and grants (*bolsas,* or "purses") are given to women, mothers, babies, schoolchildren, and youth. The grants come with conditions. The *bolsa familiar* (family grant), a small cash payment to each mother and up to five of her young children, requires the mother to immunize her babies, attend to their medical needs, follow medical directions, keep the children in school, monitor their homework, help them prepare for exams, and purchase school books, pens and pencils, and school clothes. Of the thirty Alto women between the ages of seventeen and forty my research associate, Jennifer S. Hughes, and I interviewed in June, the women averaged 3.3 preg-


JENNIFER S. HUGHES

Dona Amantina (left), who maintains the ledgers at the municipality's official registry office, updates the author on birth and death statistics.

JENNIFER S. HUGHES

While waiting to be seen by a nurse-assistant in the public clinic on the Alto do Cruzeiro—there is no doctor—pregnant women are interviewed by the author (foreground) in June 2013. A primary dilemma and anxiety they face is the lack of obstetricians in Timbaúba, a municipality of 55,000 people. On arrival in labor at the local hospital they are often, reluctantly, sent by ambulance to hospitals in the capital city of Recife, sixty-seven miles away. It's a risky and bumpy two-hour drive, and during rush hour there are traffic jams in Recife. Many women insist on scheduling a C-section before their due date, rather than risk making the trip after going into labor.

nancies—higher than the national average, but the real comparison here is with their own mothers, who (based on the thirteen of the thirty who could describe their mothers' reproductive histories) averaged 13.6 pregnancies and among them counted sixty-one infant deaths. Jennifer is my daughter and a professor of colonial and postcolonial Latin American history at the University of California, Riverside. I like to think that her awesome archival skills were honed more than twenty years ago when I enlisted her, then a teenager, to help me count the deaths of Alto babies in the civil registry office. She agreed to help me on this most recent field trip, and it was our first professional collaboration.

Jennifer, for example, looked up Luciene, the first-born daughter of Antonieta, one of my earliest key informants and my neighbor when I lived on the Alto do Cruzeiro. Now in her forties, Luciene had only one pregnancy and one living child. Her mother had given birth to fifteen babies, ten of whom survived. Daughter and mother now live next door to each other, and they spoke openly and emotionally about the "old days," "the hungry times," "the violent years," in comparison to the present. "Today we are rich," Antonieta declared, "*really* rich," by which she meant her modernized home on the Alto Terezinha, their new color television set, washing machine, and all the food and delicacies they could want.

Four of the thirty women we interviewed had lost an infant, and one had lost a two-year-old who drowned playing with a large basin of water. Those deaths were seen as tragic and painful memories. The mothers did not describe the deaths in a monotone or dismiss them as inevitable or an act of mercy that relieved their suffering. Rather, they recalled with deep sadness the date, the time, and the cause of their babies' deaths, and remembered them by name, saying that Gloria would be ten today or that Marcos would be eight years old today, had she or he lived.

What has happened in Timbaúba over the past decades is part of a national trend in Brazil. Over the past decade alone, Brazil's fertility rate has decreased from 2.36 to 1.9 children per family—a number that is below the replacement rate and lower than that of the United States. Unlike in China or India, this repro-

Expecting her second child in 2006, this teenage girl was able to give birth in the local hospital, because the doctor shortage was not as acute at that time. She was looking forward to breastfeeding her newborn and confident that her two babies were enough. She could look forward to their survival, thanks to the many medical and social safety nets that had been put into place.

NANCY SCHEPER-HUGHES

ductive revolution occurred without state coercion. It was a voluntary transition, and a rapid one.

A footnote in *Death Without Weeping* records the most common requests that people made of me in the 1960s and again in the 1980s: Could I possibly help them obtain false teeth? a pair of eyeglasses? a better antibiotic for a sick older child? But most often I was asked—begged—by women to arrange a clandestine sterilization. In Northeast Brazil, sterilization was always preferable to oral contraceptives, IUDs, and condoms. Reproductive freedom meant having the children you wanted and then "closing down the factory." *"A fábrica é fechada!"* a woman would boastfully explain, patting her abdomen. Until recently, this was the privilege of the upper middle classes and the wealthy. Today, tubal ligations are openly discussed and arranged. One woman I interviewed, a devout Catholic, gushed that God was good, so good that he had given her a third son, her treasure trove, and at the same time had allowed her the liberty and freedom of a tubal ligation. "Praise to God!" she said. "Amen," I said.

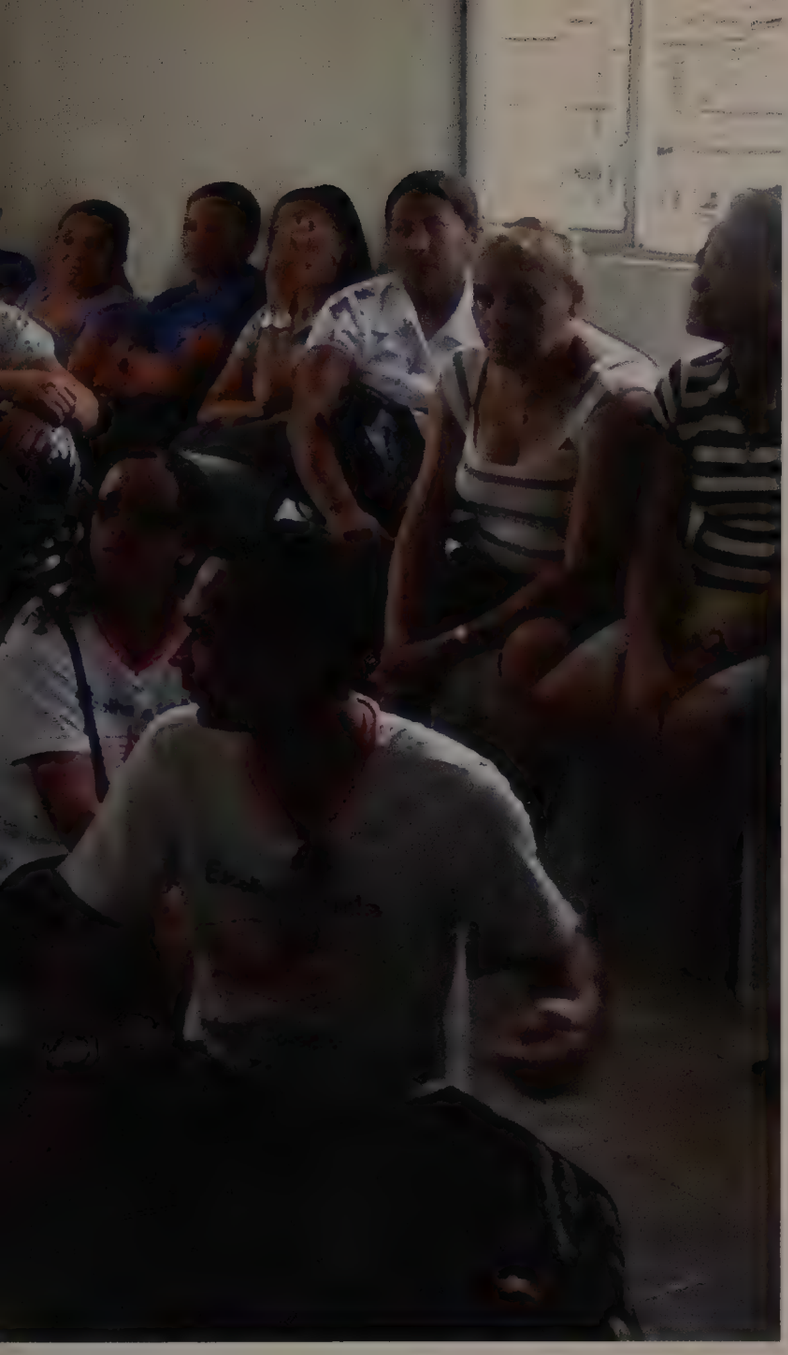
In Brazil, the reproductive revolution is linked to democracy and the coming into political power of President Fernando Henrique Cardoso (1995–2002), aided by his formidable wife, the anthropologist and women's advocate Ruth Cardoso. It was continued by Luiz Inácio Lula da Silva, universally called "Lula," and, since 2011, by his successor, Dilma Rousseff. President Lula's Zero Hunger campaign, though much criticized in the popular media as a kind of political publicity stunt, in fact has supplied basic foodstuffs to the most vulnerable households.

PROGRAMA DE AGENTE COMUNITÁRIO DE SAÚDE

A meeting of Timbaúba health agents: The basic qualification is to complete middle school, following which prospective applicants compete for the job by taking a rigorous exam. Their duties include identifying and reporting communicable diseases, acting as public-health and environmental educators, and participating in public meetings to shape health policies.

Today food is abundant on the Alto. Schoolchildren are fed nutritious lunches, fortified with a protein mixture that is prepared as tasty milk shakes. There are food pantries and state and municipal milk distribution programs that are run by women with an extra room in their home. The monthly stipends to poor and single mothers to reward them for keeping their children in school has turned elementary school pupils into valuable household "workers," and literacy has increased for both the children and their mothers, who study at home alongside their children.

When I first went the Alto in 1964 as a Peace Corps volunteer, it was in the role of a *visitadora*, a public-health community worker. The military dictatorship was suspicious of the program, which mixed health education and immunizations with advocating for water, street lights, and pit latrines as universal entitlements—owed even to those who had "occupied public land" (like the people of the Alto, who had been dispossessed by modernizing sugar plantations and mills). The *visitadora* program, Brazil's version of Chinese "barefoot doctors," was targeted by the military government as subversive, and the program ended by 1966 in Pernambuco. Many years later President Cardoso fortified the national health care system with a similar program of local "community health agents," who live and work in their micro-communities, visiting at-risk households, identifying crises, diagnos-



ing common symptoms, and intervening to rescue vulnerable infants and toddlers from premature death. In Timbaúba, there are some 120 community health agents, male and female, working in poor micro-communities throughout the municipality, including dispersed rural communities. On the Alto do Cruzeiro twelve health agents each live and work in a defined area, each responsible for the health and well-being of some 150 families comprising 500 to 600 individuals. The basic requirement for a health worker is to have completed *ensino fundamental,* the equivalent of primary and middle school. Then, he or she must prepare for a public *concurso,* a competition based on a rigorous exam.

The community health agent's wage is small, a little more than the Brazilian minimum wage, but still less than US $700 a month for a forty-hour work week, most of it on foot up and down the hillside "slum" responding to a plethora of medical needs, from diaper rash to an emergency home birth. The agent records all births, deaths, illnesses, and other health problems in the micro-community; refers the sick to health posts, emergency rooms, and hospitals; monitors pregnancies and the health of newborns, the disabled, and the elderly. He or she identifies and reports communicable diseases and acts as a public-health and environmental educator. The agent participates in public meetings to shape health policies. Above all, the community health agent is the primary intermediary between poor people and the national health care system.

I am convinced that the incredible ddecline in premature deaths and useless suffering that I witnessed on the Alto is primarily the result of these largely unheralded medical heroes, who rescue mothers and their children in a large town with few doctors and no resident surgeons, pediatricians, and worst of all, obstetricians. A pregnant woman of the Alto suffers today from one of the worst dilemmas and anxieties a person in her condition can face: no certain location to give birth. The only solution at present is to refer women in labor to distant obstetric and maternity wards in public hospitals in Recife, the state capital, a sixty-seven-mile drive away. The result can be fatal: at least one woman in the past year was prevented (by holding her legs together) from delivering her baby in an ambulance, and both mother and child died following their arrival at the designated hospital in Recife. For this reason Alto women and their health agents often choose prearranged cesarian sections well in advance of due dates, even though they know that C-sections are generally not in the best interest of mothers or infants.

Then, beyond the human factor, environmental factors figure in the decline in infant mortality in the shantytowns of Timbaúba and other municipalities in Northeast Brazil. The most significant of these is the result of a simple, basic municipal public-health program: the installation of water pipes that today reach nearly all homes with sufficient clean water. It is amazing to observe the transformative potential of material conditions: water = life!

Finally, what about the role of the Catholic Church? The anomaly is that, in a nation where the Catholic Church predominates in the public sphere and abortion is still illegal except in the case of rape or to save a mother's life, family size has dropped so sharply over the last two decades. What is going on? For one thing, Brazilian Catholics are independent, much like Catholics in the United States, going their own way when it comes to women's health and reproductive culture. Others have simply left Catholicism and joined evangelical churches, some of which proclaim their openness to the reproductive rights of women and men. Today only 60 percent of Brazilians identify as Roman Catholic. In our small sample of thirty women of the Alto, religion—whether Catholic, Protestant, Spiritist, or Afro-Bra-

zilian—did not figure large in their reproductive lives.

The Brazilian Catholic Church is deeply divided. In 2009, the Archbishop of Recife announced the Vatican's excommunication of the doctors and family of a nine-year-old girl who had had an abortion. She had been raped by her stepfather (thus the abortion was legal), and she was carrying twins—her tiny stature and narrow hips putting her life in jeopardy. After comparing abortion to the Holocaust, Archbishop José Cardoso Sobrinho told the media that the Vatican rejects believers who pick and choose their moral issues. The result was an immediate decline in church attendance throughout the diocese.

Government grants made to poor mothers require them to immunize their babies, attend to their medical needs, and keep their children in school.

While the Brazilian Catholic hierarchy is decidedly conservative, the rural populace, their local clerics, and liberation theologians such as the activist ex-priest Leonardo Boff are open in their interpretations of Catholic spirituality and corporeality. The Jesus that my Catholic friends on the Alto embrace is a sensitive and sentient Son of God, a man of sorrows, to be sure, but also a man of compassion, keenly attuned to simple human needs. The teachings of liberation theology, while condemned by Pope John Paul II, helped to dislodge a baroque folk Catholicism in rural Northeast Brazil that envisioned God and the saints as authorizing and blessing the deaths of angel babies.

Padre Orlando, a young priest when I first met him in 1987, distanced himself from the quaint custom of blessing the bodies of dead infants as they were carried to the municipal graveyard in processions led by children. He also invited me and my Brazilian research assistant to give an orientation on family planning to poor Catholic women in the parish hall. When I asked what form of contraception I could teach, he replied, "I'm a celibate priest, how should I know? Teach it all, everything you know." When I reminded him that only the very unpredictable rhythm method was approved by the Vatican, he replied, "Just teach it all, everything you know, and then say, but the Pope only approves the not-so-safe rhythm method."

The people of the Alto do Cruzeiro still face many problems. Drugs, gangs, and death squads have left their ugly mark. Homicides have returned with a vengeance, but they are diffuse and chaotic, the impulsive murders one comes to expect among poor young men—the unemployed, petty thieves, and small-time drug dealers—and between rival gangs. One sees adolescents and young men of the shantytowns, who survived that dangerous first year of life, cut down by bullets and knives at the age of fifteen or seventeen by local gangs, strongmen, bandidos, and local police in almost equal measure. The old diseases also raise their heads from time to time: schistosomiasis, Chagas disease, tuberculosis, and even cholera.

But the bottom line is that women on the Alto today do not lose their infants. Children go to school rather than to the cane fields, and social cooperatives have taken the place of shadow economies. When mothers are sick or pregnant or a child is ill, they can go to the well-appointed health clinic supported by both state and national funds. There is a safety net, and it is wide, deep, and strong.

Just as we were leaving in mid-June, angry, insurgent crowds were forming in Recife, fed up with political corruption, cronyism, and the extravagant public expenditures in preparation for the 2014 World Cup in Brazil—when the need was for public housing and hospitals. Those taking to the streets were mostly young, urban, working-class and new middle-class Brazilians. The rural poor were generally not among them. The people of the Alto do Cruzeiro (and I imagine in many other communities like it) are strong supporters of the government led by the PT (Partido dos Trabalhadores, or Workers' Party). Under the PT the government has ended hunger in Pernambuco, and has opened family clinics and municipal schools that treat them and their children with respect for the first time in their lives.

The protesters in the streets are among the 40 million Brazilians who were added to the middle class between 2004 and 2010, under the government of President Lula, and whose rising expectations are combustible. When the healthy, literate children of the Alto do Cruzeiro grow up, they may yet join future protests demanding more accountability from their elected officials.

A version of this article appeared in The Berkeley Review in Latin American Studies, *Spring 2013.*

Nancy Scheper-Hughes's renowned book *Death Without Weeping* was preceded by her *Natural History* article of the same title in October 1989. More recently Scheper-Hughes contributed "Truth and Rumor on the Organ Trail" (October 1998). Scheper-Hughes's most recent books are *Commodifying Bodies,* co-edited with Loic Waquant (Sage Publications Ltd, 2002), and *Violence in War and Peace: An Anthology,* co-edited with Philippe Bourgois (Basil Blackwell Ltd, 2003). An updated and abridged paperback edition of *Death Without Weeping* will be published by the University of California Press in the summer of 2014. Scheper-Hughes is Chancellor's Professor of Anthropology at the University of California, Berkeley, and the cofounder and director of Organs Watch, a medical human-rights project.

SKYLOG BY JOE RAO

LIBRARY OF CONGRESS

Cygnus, the Swan, dominates a constellation card from Urania's Mirror, a boxed set published ca. 1825.

No fewer than nine of the eighty-eight recognized constellations are named after various kinds of birds. Only two of them—Cygnus, the Swan, and Aquila, the Eagle—are lodged firmly in the Northern Hemisphere's sky, but they are far and away the finest of the lot, each containing a 1st-magnitude star. Both birds are excellently placed for viewing, high overhead and toward the south, late on September evenings.

Interestingly, between Cygnus and Aquila there once was a goose named Anser, carried in the mouth of a little fox, Vulpecula. Both those inconspicuous star groups were among a number introduced by Johannes Hevelius of Danzig, in his posthumously published star atlas of 1690. Sadly for bird lovers, the Goose has long been forgotten (but the Little Fox is still there).

During northerners' autumn months, two other birds peek above the southern and southeastern horizons: Grus, the Crane, and Phoenix, the mythical up-from-the-ashes bird. Both are star patterns of the southern sky based on observations made in the 1590s by the Dutch mariner Pieter Dirkszoon Keyzer. Keyzer was the chief navigator on the first Dutch expedition to the East Indies (Indonesia). As instructed by the cartographer Petrus Plancius, he charted the night sky south of the equator.

Keyzer didn't survive what proved to be a long and difficult voyage, but his catalog of stars did. On that basis Plancius (or possibly Keyzer himself) named a total of twelve southern constellations, all of which are still officially recognized. The namer apparently was keen on exotic birds. Along with Grus and Phoenix, he also created Apus, the Bird of Paradise; Pavo, the Peacock; and Tucana, the Toucan. Those three constellations are too far south to be seen from mid-northern latitudes. The other seven are a mixed bag, none of them birds, unless you want to count Volans, the Flying Fish.

Rounding up the total of nine bird constellations worldwide are Columba, the Dove, named by Plancius prior to Keyzer's voyage and just starting to be visible from mid-northern latitudes in September, and Corvus, the Crow, known to the ancient Greeks and visible from January into early July.

Joe Rao is a broadcast meteorologist and an associate and lecturer at the Hayden Planetarium in New York City (www.haydenplanetarium.org).

SEPTEMBER NIGHTS OUT

2 Beginning about three hours before sunup, look low toward the east-northeast to find the slender crescent Moon. Mars is about 7 degrees above and left of the Moon.

5 The Moon is new at 7:36 A.M. eastern daylight time (EDT). This evening between sunset and nightfall, Venus is passing by the 1st-magnitude star Spica, less than 2 degrees to the planet's lower left.

8 Early this morning and tomorrow morning, Mars skims through the southern fringes of Messier 44, the Beehive cluster in Cancer. In the evening sky, Venus, which has been languishing low in the dusk all summer, manages to stay above the horizon practically to the very end of evening twilight. About forty-five minutes after sunset, look toward the southwest horizon to see Venus hovering a couple of degrees above and to the right of a crescent Moon.

9 Yellowish Saturn, the brightest evening planet next to Venus, sits in the southwest at dusk, about 10 degrees to the upper left of Venus. The crescent Moon is situated 5 degrees to the left and a little below Saturn.

12 The Moon waxes to first quarter at 1:08 P.M. EDT.

18 Venus passes 3 1/2 degrees below and to the left of Saturn.

19 The Moon is full at 7:13 A.M. EDT. Because it is the full Moon nearest to the autumnal equinox, coming on the 22nd, most calendars and almanacs term this the "Harvest Moon." Others, however, reserve that term for the first full Moon in autumn, which has yet to begin.

22 At 4:44 P.M. EDT, the Sun heads south across the celestial equator, Earth's equator projected onto the heavens. This equinox marks the beginning of autumn in the Northern Hemisphere and spring in the Southern.

26 The Moon wanes to last quarter at 11:55 P.M. EDT.

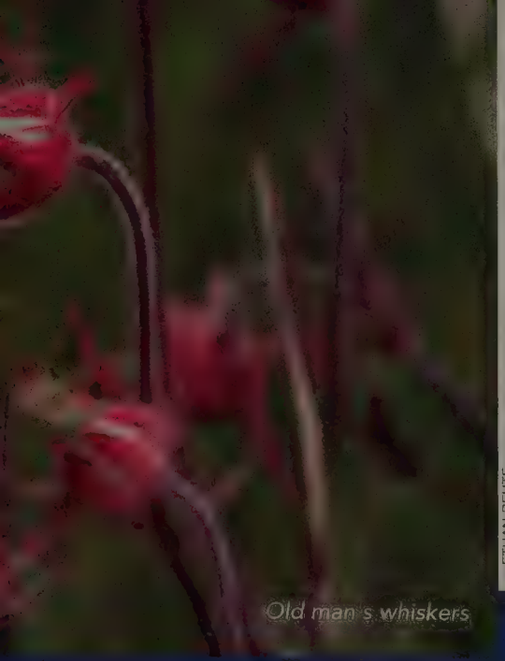
28 Around 1 A.M. local daylight time, look low near the east-northeast horizon to find Jupiter hovering about a half dozen degrees above and to the left of the crescent Moon.

THIS LAND BY ROBERT H. MOHLENBROCK

Canyon on the Plains

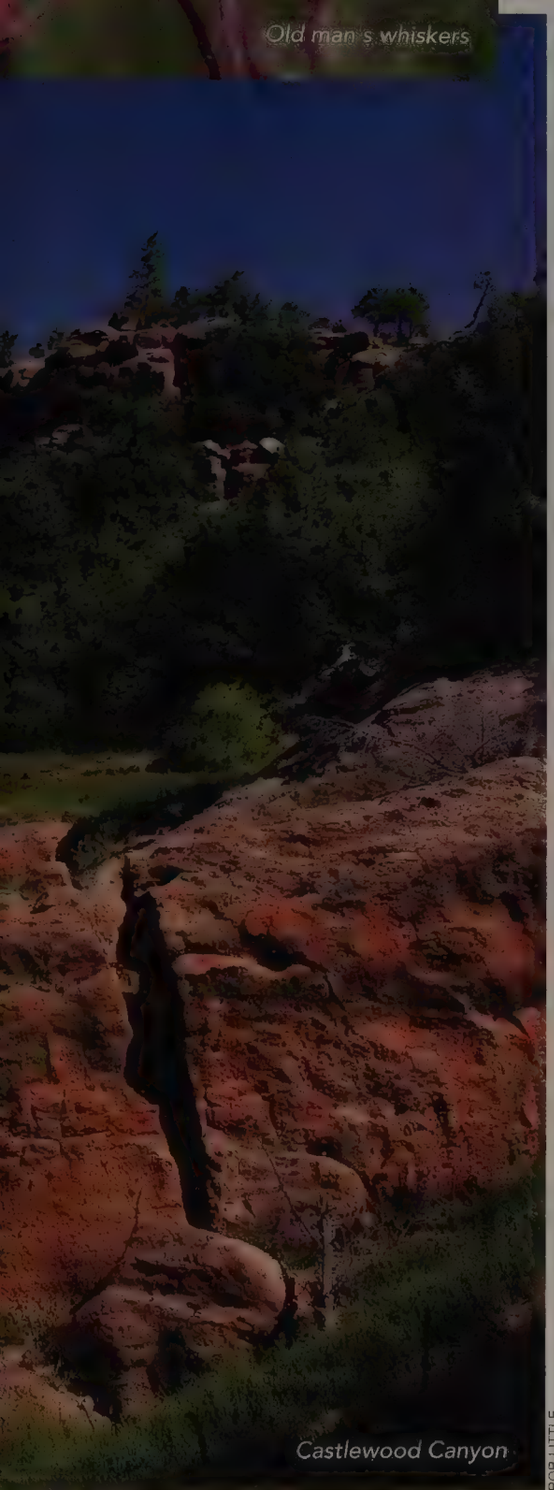
Colorado's Cherry Creek provides relief.

All but one of the natural areas I have studied in Colorado have been west of Interstate Highway 25, the corridor that extends north to south from Fort Collins to Denver to Colorado Springs to Pueblo. This marvelous region includes the montane forest and, above the timberline, tundra of the Rocky Mountains; the Grand Mesa area in far western Colorado; and the Great Sand Dunes of the southern part of the state. Travel-



ETHAN BEUTE

Old man's whiskers



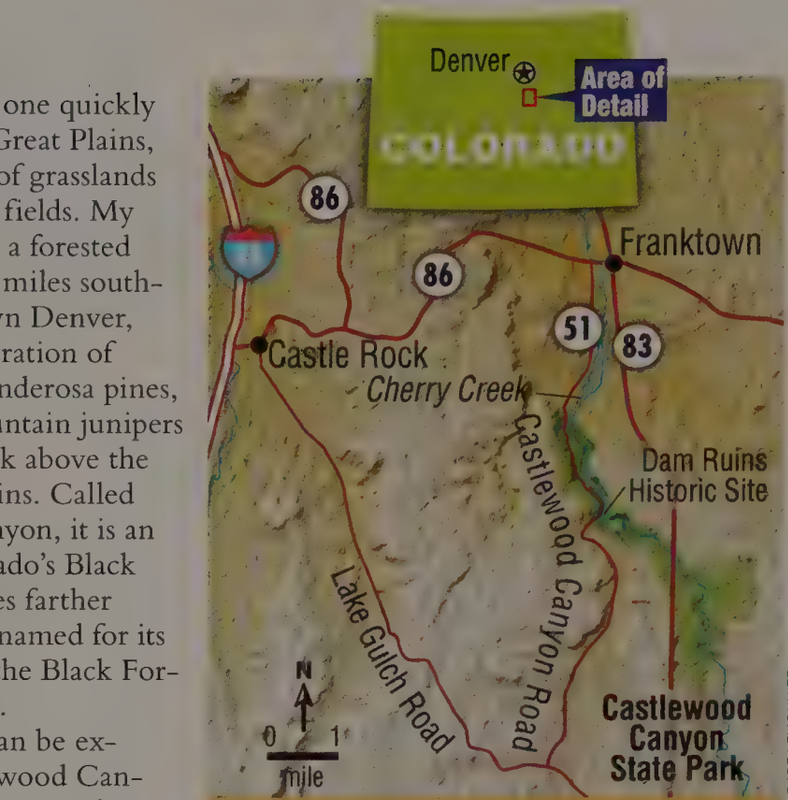
ROB LITTLE

Castlewood Canyon

ing east of I-25, one quickly encounters the Great Plains, a flat landscape of grasslands and agricultural fields. My one exception is a forested area about forty miles southeast of downtown Denver, where a concentration of Douglas firs, ponderosa pines, and Rocky Mountain junipers appears very dark above the surrounding plains. Called Castlewood Canyon, it is an outlier of Colorado's Black Forest, which lies farther south (and is so named for its resemblance to the Black Forest in Germany).

The canyon can be explored in Castlewood Canyon State Park, centered on Cherry Creek. The creek began carving its channel some 34 million years ago, cutting through rock layers deposited by streams flowing from the west, out of the uplifting Front Range. The oldest layers exposed today, dating from about 55 million years ago, are of conglomerate, sandstone, and mudstone and are called Dawson Arkose. These are capped in places by a younger deposit known as Castle Rock Conglomerate. Made up of streambed cobbles and sand that have been cemented together, this hard layer is more resistant than the valley walls, forming cliffs above the broad lower slopes of the canyon.

During the second half of the nineteenth century, settlers began arriving in the area to establish dairy farms, ranches, truck gardens, potato fields, and orchards. These supplied the growing city of Denver. To attract land buyers by assuring a reliable water supply for irrigation, several landowners concocted a plan to dam Cherry Creek a few miles south of the town of Franktown. Taking eleven months to build of rocky rubble and masonry by man-, horse-, and mule power, Castlewood Dam became a reality in 1890. It was 600 feet wide, 70 feet tall, 8 feet thick at the top, and 85 feet thick at the bottom. The result was a reservoir that could hold 5,300 acre-feet of water, fed by a 200-square-mile drainage.



©JOE LEMONNIER

VISITOR INFORMATION
Castlewood Canyon State Park
2989 South State Highway 83
Franktown, CO 80116
303-688-5242
www.parks.state.co.us/parks/castlewoodcanyon

ETHAN BEUTE

Yellow salsify

From the very beginning, critics feared that the dam would not be strong enough to hold water back in case of torrential rains. Only six months

Cherry Creek

Wild blue flax

ETHAN BEUTE

after its completion, a tiny leak in the dam required attention. Seven years later, in 1897, there was a 100-foot washout that had to be repaired. Thereafter, the dam seemed to be holding up until heavy rain fell from July 30 through August 2, 1933, culminating in a downpour the evening of August 2 that dropped eight inches of water in a period of three hours.

This was more than the dam could tolerate, and it collapsed in the wee hours of the morning, releasing thunderous cascades of water that could be heard two miles away. As telephone operators raced to warn people to move their families and animals to high ground, the

HABITATS

Creekside Trees include box elder, eastern cottonwood, narrowleaf cottonwood, peachleaf willow, sandbar willow, and water birch. Among the shrubs and small trees are dewystem willow, mountain ninebark, park willow, Scouler's willow, and western chokecherry. Other wetland plants found along and sometimes in Cherry Creek include American water horehound, arumleaf arrowhead, two kinds of beggarticks, bog yellowcress, cursed buttercup, fringed yellow loosestrife, golden banner, northern water plantain, pinkweed, purple meadow rue, slenderleaf false foxglove, and an assortment of sedges.

Stone crevice Ferns include Fendler's false cloak fern, maidenhair spleenwort, New Mexico cliff fern, Oregon cliff fern, Rocky Mountain woodsia, and slender lipfern. Other plants that grow in rock crevices are harebell and yellowdot saxifrage.

Forest Douglas fir, Gambel's oak, ponderosa pine, and Rocky Mountain juniper are the major trees; shrubs in the understory include common American plum, beaked hazelnut, Fendler's buckbrush, giant red Indian paintbrush, juniper, thimbleberry, wax currant, white snowberry, and Woods's rose. Among the wildflowers that bloom in the spring on the forest floor are Colorado columbine, Fendler's rockcress, littleleaf pussytoes, Macoun's buttercup, maiden blue-eyed Mary, Nuttall's larkspur, pale madwort, pasqueflower, starry false Solomon's-seal, western dog violet, and western spring beauty. Those that appear later include blue mist penstemon, fairy trumpets, fragrant bedstraw, heartleaf arnica, largeflower Townsend daisy, and Richardson's alumroot.

Sandstone pavement There are a few scattered trees, such as Gambel's oak and Rocky Mountain juniper, and a few shrubs, such as fragrant sumac and soapwort yucca. Low-growing vegetation includes flat-top pussytoes, plains spring parsley, silvery lupine, spreading sandwort, winged buckwheat, woolly plantain, and yellow stonecrop. Two cacti found here are plains prickly pear and Simpson's hedgehog; among the spore-producing plants are

ETHAN BEUTE

impounded waters of Cherry Creek roared vociferously northward, destroying almost everything in their path. The wall of water crushed the tiny communities of Franktown and Parker and barreled into downtown Denver at dawn, destroying six city bridges along the way. Two people died, a fashionable residential district in Denver was heavily flooded, and several businesses and the popular Sunken Gardens of Denver were destroyed. The damage was estimated at $1 million. Remains of the dam may be seen today in Castlewood Canyon State Park.

There are two routes to the park. The main entrance is five miles south of Franktown, just off of State Highway 83. The road ends at the small visitor's center from which hiking trails may be taken across rock flats to various observation points overlooking the canyons. A second entrance is off Castlewood Canyon Road (County Highway 51), which branches south off State Highway 86 just west of Franktown. This road leads to trails that pass along the edge of Cherry Creek.

ETHAN BEUTE

Cherry Creek is filled with rocks and boulders of every size, and the crevices in the canyon walls provide niches for rock-loving plants, known as petrophytes. The canyons are forested, as well as some of the cliff tops. Several flat areas on top of the bluffs provide habitat for a sandstone pavement community. Interspersed here and there in the park are open meadows, host to various plants of the prairies and plains. In addition, a number of weedy plants, some with colorful flowers, grow along the park roads.

Apart from the remains of Castlewood Dam, history buffs may be interested in the ruins of the homestead of one of the locale's early inhabitants, Patrick Lucas, who built the structures between 1894 and 1910 for his wife Margaret and their eight children.

ROBERT H. MOHLENBROCK is a distinguished professor emeritus of plant biology at Southern Illinois University Carbondale.

dense spikemoss and forked spleenwort.

Meadow Among the myriad wildflowers are blackeyed Susan, Canada goldenrod, carpet phlox, death camas, green gentian, Mariposa lily, northern Idaho biscuitroot, old man's whiskers, orange paintbrush, prairie spiderwort, purple prairie clover, upright prairie coneflower, western wallflower, White River coraldrops, and wild blue flax.

Roadside Plants colonizing disturbed soil include bouncing bet, common sunflower, cowboy's delight, golden crownbeard, Norwegian cinquefoil, Rocky Mountain beeplant, showy milkweed, spreading dogbane, sticky gumweed, and yellow salsify.

Around the Country

Celebrating a Bicentennial

Two hundred years ago—before the nation was yet 40 years old, before the United States declared war on the British Empire—a group of amateur naturalists met in a Philadelphia cake shop to form The Academy of Natural Sciences.

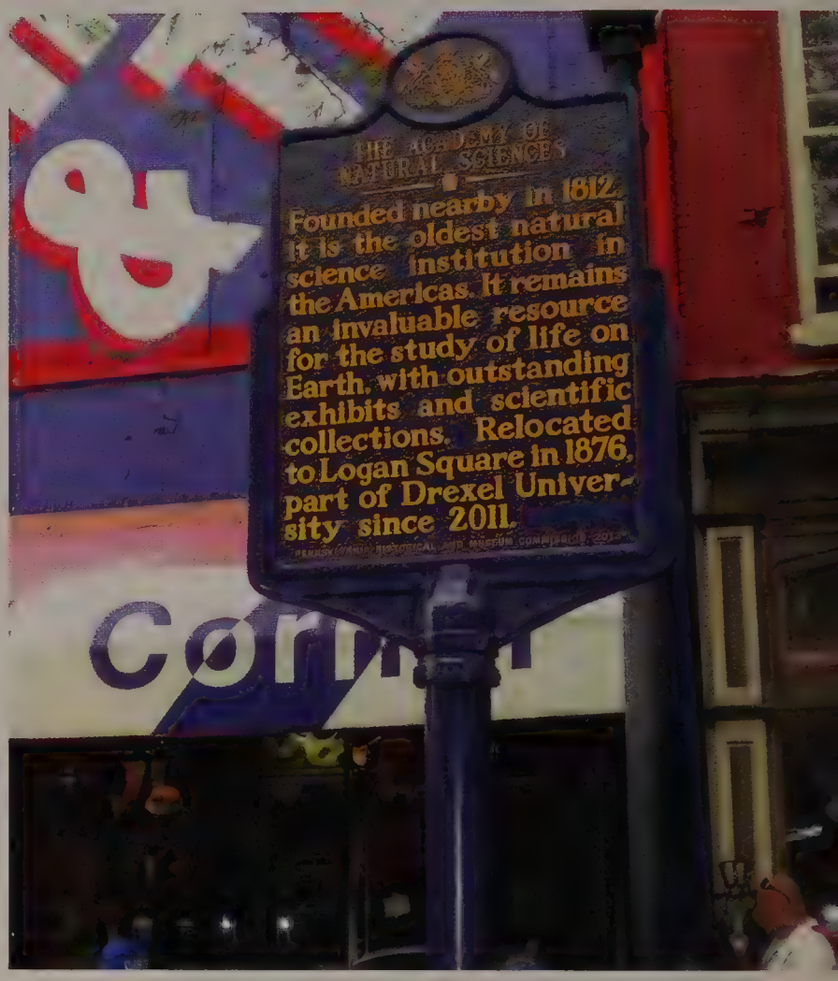
It was on March 21, 1812, that the group of six men in their 20s founded an organization "for the encouragement and cultivation of the sciences, and the advancement of useful learning."

"They were just well-educated, enthusiastic naturalists who thought that by sharing their specimens, their libraries, their knowledge, and their enthusiasm, they could accomplish much more together as a group," said Robert Peck, a senior fellow at the academy.

The academy grew slowly, for a time housing its donated books, dried plants, and stuffed birds in a room above a milliner's shop. It next moved to a house, then operated from a variety of ever-larger buildings, and finally moved to its present location in 1876.

During a ceremony recently, officials gathered in the oldest part of Philadelphia to dedicate a historical marker near the site of the old cake shop, which no longer exists.

After 200 years, the academy, now a part of Drexel University, has grown its collection to about 18 million specimens, employs a scientific staff of 150 people, and still continues to advance useful learning.



A marker at 302 Market Street, in Philadelphia's Old City neighborhood, marks the spot where The Academy of Natural Sciences was founded in 1812.

ARIZONA

Mesa

ARIZONA MUSEUM OF NATURAL HISTORY

Ongoing: **"Rulers of the Prehistoric Skies."** Meet the pterosaurs, the largest animals that have ever flown, in this new exhibition examining the winged reptiles that lived from 225 to 65 million years ago. Find out about the *Quetzalcoatlus northropi* and its 39-foot wingspan, the fish-eating *Nyctosaurus*, the toothed *Dsungaripterus*, and many other animals that were neither birds nor dinosaurs.

53 North Macdonald
480-644-2230
www.azmnh.org

Phoenix

ARIZONA SCIENCE CENTER

Ongoing: **"Forces of Nature."** Experience some of the raw power generated by a dynamic Earth, including phenomena such as earthquakes, hurricanes, tornadoes, volcanic eruptions, and wildfires. Find out what Earth scientists do and what their work reveals. The Immersion Theater puts you in the center of the action, and hands-on exhibits help explain the underlying science of plate tectonics, ocean currents, wind patterns, and more.

600 East Washington Street
602-716-2000
www.azscience.org

CALIFORNIA

Los Angeles

NATURAL HISTORY MUSEUM OF LOS ANGELES COUNTY

Ongoing: **"Dinosaur Hall."** Get up close to the terrible lizards in this gallery featuring more than 300 fossils and 20 complete mounts of dinosaurs and sea creatures. Stroll beneath a 68-foot *Mamenchisaurus*, see the world's only display of differently aged *T. rex* specimens (baby, juvenile, and sub-adult), see the preserved remains of a dinosaur's last meal, and more.

Exposition Park
900 Exposition Boulevard
213-763-DINO
www.nhm.org

San Diego

SAN DIEGO NATURAL HISTORY MUSEUM

Ongoing: **"Fossil Mysteries."** Dioramas, fossils, models, murals, and plenty of hands-on activities tell the changing story of the bioregion encompassing southern California and Baja California in this exhibition spanning 75 million years of history. Examine fossil clues—just as scientists do—to answer questions about plants and animals (including dinosaurs), changing environments, evolution, extinction, and more.
Balboa Park
1788 El Prado
619-232-3821
www.sdnhm.org

COLORADO

Denver

DENVER MUSEUM OF NATURE AND SCIENCE
Ongoing: **"Prehistoric Journey."** Hike an indoor "trail through time," with detailed information and fossil specimens from seven periods in the 3.5 billion-year history of life on Earth. Unique "enviroramas" (reconstructed ancient habitats) along the trail—full of things to see, hear, and touch—make it seem as if you're walking in the past.
2001 Colorado Boulevard
303-370-6000
www.dmns.org

CONNECTICUT

New Haven

PEABODY MUSEUM OF NATURAL HISTORY
Ongoing: **"Hall of Minerals, Earth, and Space."** This geological exhibition explores the birth of the solar system and the forces that shaped the Earth's early geology: earthquakes, volcanic eruptions, and meteorite collisions. Discover how the planet's rocky surface—on land and under the oceans—interacts with the atmosphere and waters to create Earth's livable climate. From the museum's vast collections, see rare gems as well as minerals with unusual properties such as vivid colors, fluorescence, magnetism, and radioactivity.
Yale University
170 Whitney Avenue
203-432-5050
www.peabody.yale.edu

DELAWARE

Wilmington

DELAWARE MUSEUM OF NATURAL HISTORY
Through September 2: **"Water's Extreme Journey."** Find out about watersheds and their inhabitants in this exhibition developed with Wyland, the marine-life artist. Just like a raindrop, you can wind your way through lakes, rivers, wetlands, and other bodies of water. Along the way, find out about pollutants that come from agriculture, homes, litter, and other sources.
4840 Kennett Pike
302-658-9111
www.delmnh.org

FLORIDA

Gainesville

FLORIDA MUSEUM OF NATURAL HISTORY
Through August 11: **"*Titanoboa:* Monster Snake."** Florida Museum of Natural History scientists recently discovered 60-million-year-old remains of the largest snake in the world, *Titanoboa cerrejonensis,* in a Colombian coal mine. Measuring 48 feet long and weighing 2,500 pounds, this massive predator could crush and devour a crocodile! In this new exhibition, visit a coal mine and explore what life was like in the Paleocene Epoch, meet a full-scale model of *Titanoboa,* see the paleontology lab where scientists work on real fossils, and more.
University of Florida
Cultural Plaza
SW 34th Street and Hull Road
352-846-2000
www.flmnh.ufl.edu

Tampa

MUSEUM OF SCIENCE AND INDUSTRY (MOSI)
Through September 2: **"Sea Monsters Revealed."** Walk through the depths of the sea and meet some marine behemoths—including a giant squid, a 6-foot-wide manta ray, a 3,000-pound whale shark, and more—that have been preserved with polymers. The exhibition's immersive environments also include a Natural Scientist's Study with early specimens, a Submersible with an operable robotic arm, a cutting-edge Infinite Scuba video game, and many other marine-science experiences.
4801 East Fowler Avenue
813-987-6100
www.mosi.org

GEORGIA

Atlanta

FERNBANK MUSEUM OF NATURAL HISTORY
Through August 18: **"Extreme Mammals."** Examine some of the oddest and most intriguing animals of all time. From the speedy to the slothful, the towering to the tiny, and the furry to the armor-clad, come nose-to-snout with an amazing array of extraordinary critters. Stand beneath the largest land mammal that ever lived, and peek at a creature so small that it weighed no more than a dollar bill!
767 Clifton Road NE
404-929-6300
www.fernbankmuseum.org

HAWAII

Honolulu

BISHOP MUSEUM
Ongoing: **"Hawaiian Hall."** A stunning renovation of the museum's original building features dramatic artifacts, fascinating videos, and intriguing interactive exhibits that illuminate the state's natural and cultural history. Try identifying flowers by their smell, walk inside a thatched *hale* dwelling, examine the inside of a 50-foot sperm whale, and more.
1525 Bernice Street
808-847-3511
www.bishopmuseum.org

MEMBERSHIP HAS ITS REWARDS

Institutions marked with participate in the Passport program run by the Association of Science-Technology Centers (ASTC). If you're a member of a participating museum or science center, you may receive free admission at nearly 350 other museums and science centers around the world.

See www.astc.org/passport for more information.

THE ACADEMY OF NATURAL SCIENCES/KAREN SPIRO

IDAHO

Idaho Falls

MUSEUM OF IDAHO

Ongoing: **"Lewis and Clark in Idaho."** Join the storied explorers' Corps of Discovery and make your way through the Idaho they encountered in 1805 while on their journey into the West. Visit a Shoshone village, see some of the types of animals Lewis and Clark encountered, find out about the impact of the expedition, and more.

200 North Eastern Avenue
208-522-1400
www.museumofidaho.org

ILLINOIS

Chicago

THE FIELD MUSEUM

Through January 5, 2014: **"Creatures of Light: Nature's Bioluminescence."** From glowworms to deep-sea fishes, immerse yourself in the mysterious and magical world of bioluminescence and discover the thousands of living organisms that blink, glow, flash, and flicker.

1400 South Lake Shore Drive
312-922-9410
www.fieldmuseum.org

MASSACHUSETTS

Cambridge

HARVARD MUSEUM OF NATURAL HISTORY

Through February 2014: **"Mollusks: Shelled Masters of the Marine Realm."** Find out about the amazing diversity and history of mollusks—snails, clams, squid, and other invertebrates that make up almost a quarter of all known marine species. See some of the largest specimens; use magnifiers to examine some of the tiniest; discover how scientists are using cone snail venom to make medication for pain; learn about the ecology of bivalves, such as oysters and clams; and more.

26 Oxford Street
617-495-3045
www.hmnh.harvard.edu

MINNESOTA

Minneapolis

BELL MUSEUM OF NATURAL HISTORY

Through July 28: **"Dig It! The Secrets of Soil."** In this exhibition examining one of the most overlooked—and underfoot—resources on Earth, you can find out about how dirt has worked its way into thousands of everyday items including ceramics, cosmetics, fiber, food, medication, and paint. See the incredible range of soil composition in giant samples from all 50 U.S. states; meet some of the billions of microorganisms that thrive in the soil beneath each step; explore whether water moves quicker through sand, silt, or clay; and much more.

University of Minnesota
10 Church Street, SE
612-624-7083
www.bellmuseum.umn.edu

MISSOURI

Saint Louis

SAINT LOUIS SCIENCE CENTER

Ongoing: **"Ecology & Environment."** This comprehensive exhibition explores the relationships of living things with one another and with the places they inhabit. See a *T. rex* prepare to take down its dinner, an unlucky triceratops; feel the Earth move beneath your feet; find out about acidic lakes in Australia and the microbial life that thrives there; examine

A volunteer preparator works on fossils extracted from rock matrix in the "FossilWorks" exhibition at the New Mexico Museum of Natural History and Science in Albuquerque.

65-million-year-old fossils; visit an urban forest; and much more.

5050 Oakland Avenue
800-456-SLSC
www.slsc.org

NEW MEXICO

Albuquerque

NEW MEXICO MUSEUM OF NATURAL HISTORY AND SCIENCE *Ongoing:* **"FossilWorks."** This exhibition features the process of extracting dinosaur fossils from the rock matrix that has encased them for millions of years. **FossilWorks** is a public display area in which volunteer preparators—who have completed a special training course—demonstrate the painstaking process of paleontological preparation. The first dinosaur fossil prepared here was *Seismosaurus*, a New Mexico native from the Jurassic Period (150 million years old). The exhibition also features text and illustrations about fossilization, Jurassic Period dinosaurs, and preparation.

1801 Mountain Road NW
505-841-2800
www.nmnaturalhistory.org

NEW YORK

New York

AMERICAN MUSEUM OF NATURAL HISTORY

Through August 11: **"Our Global Kitchen: Food, Nature, Culture."** Explore the complex and intricate food system that brings what we eat from farm to fork. In sections devoted to growing, transporting, cooking, eating, tasting, and celebrating, the exhibition illuminates the myriad ways that food is produced and moved throughout the world. With opportunities to taste seasonal treats in the working kitchen, cook a virtual meal, see rare artifacts from the museum's collection, and peek into the dining rooms of famous figures throughout history, visitors will examine the intersection of food, nature, culture, health, and his-

tory—and consider some of the most challenging issues of our time.
Central Park West at 79th Street
212-769-5100
www.amnh.org

Tupper Lake

THE WILD CENTER, NATURAL HISTORY MUSEUM OF THE ADIRONDACKS
Ongoing: **"Living River Trail."** Follow a river's course from the mountains down to the marshlands, and along the way discover bog, forest, and stream ecosystems. You'll also find the plants and animals that live in these environments, including live river otters and rare brook trout species.
45 Museum Drive
518-359-7800
www.wildcenter.org

NORTH CAROLINA

Durham

MUSEUM OF LIFE AND SCIENCE
Ongoing: **"Flip It, Fold It, Figure It Out!—Playing with Math."** Demystifying mathematics, this new exhibition uses everyday activities to reveal the hidden math principles we all use on a regular basis. Make a quilt, slice a pizza, create rhythmic tunes, estimate which juice container holds the most liquid, and much more. Discover how architects, craftsmen, product designers, and scientists use similar skills in their work.
433 West Murray Avenue
919-220-5429
www.ncmls.org

PENNSYLVANIA

Philadelphia

THE ACADEMY OF NATURAL SCIENCES OF DREXEL UNIVERSITY
Through September 29: **"Glow: Living Lights."** Fireflies, glow worms, some fungi, and a few unfamiliar ocean creatures all do it—they "glow" with light they generate themselves. Discover what bioluminescence is, how it happens, and the varied reasons why terrestrial and aquatic organisms produce their own light.
1900 Benjamin Franklin Parkway
215-299-1000
www.ansp.org

TEXAS

Houston

HOUSTON MUSEUM OF NATURAL SCIENCE
Through December 31: **"Fabergé: A Brilliant Vision."** Step into the time of the last czars and see how natural materials, imaginative engineering, and superlative craftsmanship in the House of Fabergé workshops produced dazzling luxury objects and more "utilitarian" household items. Among the 350 objects on display are the Nobel Ice Egg, the Empress Josephine Tiara, the Diamond Trellis Imperial Egg, and a variety of dazzling cigarette cases, clocks, doorbells, purses, and more.
5555 Hermann Park Drive
713-639-4629
www.hmns.org

UTAH

Salt Lake City

NATURAL HISTORY MUSEUM OF UTAH
Ongoing: The extraordinary 163,000-square-foot **Rio Tinto Center**, situated in the foothills of the Rocky Mountains, is infused with multiple features that embrace both traditional and new media techniques. By incorporating the use of recycled materials, local resources, photovoltaic energy, radiant cooling, and the implementation of an extensive storm-water catchment and management system, the Natural History Museum of Utah will play a seminal role in enhancing the public's understanding of the Earth's resources and systems and be a model for responsible and environmentally sensitive development.
301 Wakara Way
801-581-6927
nhmu.utah.edu

WASHINGTON

Seattle

PACIFIC SCIENCE CENTER
Ongoing: **"Professor Wellbody's Health & Wellness Academy."** Investigate how you can balance diet, exercise, hygiene, and rest in this new permanent exhibition that focuses on playful learning about the human body. Watch a giant, slow-motion sneeze in the Germnasium; manage your caloric order at the Burger Planet drive-thru; explore sleep cycles in the Slumbertorium; glimpse what your future self might look like with software that ages your picture; and more.
200 Second Avenue North
206-443-2001
www.pacsci.org

WISCONSIN

Milwaukee

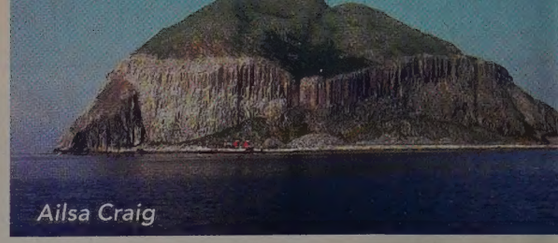
MILWAUKEE PUBLIC MUSEUM
Ongoing: **"Puelicher Butterfly Wing."** Stroll through an indoor tropical garden while native and exotic species of butterflies flutter around you; see young insects emerge from their chrysalides; discover how artistic expression in other cultures and in other times has been inspired by the beauty and movement of butterflies.
800 West Wells Street
414-278-2702
www.mpm.edu

NEW MEXICO MUSEUM OF NATURAL HISTORY AND SCIENCE; AMERICAN MUSEUM OF NATURAL HISTORY/D. FINNIN

A re-creation of one small part of the giant Aztec marketplace, which served 60,000 people a day, is part of the "Our Global Kitchen" exhibition, now at the American Museum of Natural History in New York City through August 11.

Lessons from Captives

By Bryan Nelson



Ailsa Craig

NICHOLAS TOTTEN

August is a dismal month for gannets on Ailsa Craig, a 220-acre island in Scotland's Firth of Clyde. Scores of doomed youngsters sit stoically amongst the nettles and rank grasses, fouled by droppings and molted feathers, that festoon the base of the cliffs. Some have lost their balance and fallen from their ledges, perhaps while exercising their wings, at this stage heavy with blood-filled quills. Or maybe they fell while defecating over the edge of the nest; they are not the most agile of birds. Many are knocked off their pedestals by adults landing or departing clumsily.

BRYAN NELSON

The gannets at home (left to right): J., Gilbert, and the rescued adult

My very first visit to Ailsa, now more than fifty years ago, was a character-forming few days, banding gannet chicks during an energy-sapping hot spell. My friend John Leedal and I were then picking our way beneath the cliffs when we came across three large, undamaged gannet chicks squatting forlornly in the vegetation. If only we hadn't found them! But we had, and it was unthinkable to kill them, nor could we just leave them to starve to death or be eaten alive by rats, which at that time infested Ailsa.

The only solution seemed to be to put them into empty gannet nests and just hope that adults would foster them. Jimmy Girvan, the quarryman who at that time lived on the island, had told us that such substitution did not work, but what else could we do? So we picked up our fallen chicks and carried them up to the cliff top, where we dumped them in a nest apiece and fled. At least they had a slim chance of being adopted.

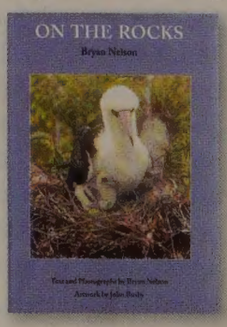
Twenty years later I came across two more chicks. This time I took them back home with romantic notions of rearing them and perhaps even persuading them to breed. Gilbert, a male, was half-grown, while J., a ten- to eleven-week-old female, had acquired all her feathers, but traces of down remained on her head.

J., Gilbert, and an injured adult that we had also picked up soon accepted piles of broken concrete slabs as their new abodes, not quite like the handsome columns of green, veined granite that they had known on Ailsa. On many a bitter winter morning, before setting off for work, I cursed my sheer lack of common sense as I hacked frozen slabs of flatfish apart and tried to thaw it enough to tempt those grim sentinels sitting impassively on their icy concrete piles through hail and rain, wind and shine.

By the age of ten months the chicks had acquired adult voices in place of the juvenile "yap," and their brown irises had lightened in color, though not yet taken on the cold gray-blue of the adult's. I was especially eager to see how their behavior might also change with age, in isolation from adult models. At about thirty-nine weeks Gilbert started to perform the gannet's territorial display, basically a ritualized ground-biting that warns off potential intruders. In fact, once he approached me and attacked my shoe, then mounted his cement slab to perform a polished version of this site-ownership display. The female, J., though five weeks older, did not develop territorial behavior at this time. In the wild, females do not establish the nesting site.

Gilbert's most interesting behavior, however, was one I had never witnessed in gannets. It was not particularly spectacular, merely a spasmodic jerking of the head with the neck retracted, head thrown back and bill pointing upwards. But it demonstrated that a complex behavior pattern, a potential display, could lie "ready-made" in the gannet's neuromuscular toolbox, even though not used in their normal repertoire. Indeed, Gilbert's behavior quite uncannily resembled the sexual advertising display of some of the cormorant species.

Gannets and cormorants, though fairly closely related, have been distinct for millions of years. Yet the cormorant's display, perfect in form, still exists within the gannet's genome alongside the very different, "new" display that the gannet now uses in a sexual context. Why the phylogenetically more primitive display was suppressed and replaced in the gannet is unknowable, like so much in animal behavior.



Adapted from On the Rocks, *by Bryan Nelson (Langford Press, 2013), text and photos © J. Bryan Nelson. A founding board member of the Scottish Seabird Centre, headquartered in North Berwick,* BRYAN NELSON *recently retired and is now the organization's ornithological advisor.*